DOCUMENT RESUME

ED 212 484 SE 036 224

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TITLE A Metric Smorgasbord: All You Can Measure for $9.99.
INSTITUTION Wyoming Univ., Laramie. Science and Mathematics Teaching Center.
PUB DATE 81
NOTE 225p.

EDRS PRICE MF01/PC09 Plus Postage.
DESCRIPTORS Elementary Secondary Education; *Instructional Materials; *Learning Activities; *Mathematical Applications; Mathematics Education; *Mathematics Instruction; Mathematics Materials; Measurement; *Metric System

ABSTRACT

Presented is a set of metric education materials developed over a five-year period by the Science and Mathematics Teaching Center (SMTC) at the University of Wyoming. It is called a "Metric Smorgasbord" because it is a set of materials which have considerable variety, were planned to appear to a broad range of instructional tastes, and permit sampling. It is comprised of three kinds of metric education materials: (1) Instructional Activities; (2) Teacher Support Materials; and (3) Construction Activities. The Instructional Activities consist of 115 color-coded activities on length, mass, volume, area, and temperature. They are designed to suggest types of measurement activities of interest to help students and teachers think and estimate in metric units. Teacher Support Materials were developed in response to teacher requests, and contain items such as excerpts from the Metric Conversion Act of 1975 and a set of sample laboratory and paper-and-pencil metric tests. Construction Activities describe 14 activities involving physical materials and games to be constructed for classroom use. (MP)

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metre ● litre ● kilogram ● degree Celsius ● metre ● litre ● kilogram ● metre

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A METRIC SMORGASBORD:
ALL YOU CAN MEASURE FOR $9.99

concocted by
Bob Kansky & Melfried Olson

flavor improved by
The Secretaries, Students, Teaching Associates and Faculty of
The Science & Mathematics Teaching Center
University of Wyoming

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A METRIC SMORGASBORD

A Few Comments on the Rationale and Menu

A COOKBOOK?

No it isn't -- neither in the sense of being a set of directions (in metric terms) for the preparation of gastronomic delights nor in the sense of being a set of lessons which are educationally programmed to the point of now-you-do-this-and-now-you-do-that. It is called a METRIC SMORGASBORD because it is a set of activities which have considerable variety, were planned to appeal to a broad range of instructional tastes and permit sampling. Like the offerings of a culinary smorgasbord, moreover, the proof of the offering in A METRIC SMORGASBORD is found only through consumption. Doers will be nourished by the SMORGASBORD; lookers will, and deserve to, starve.

WHO PREPARED THE SMORGASBORD -- AND WHY?

This set of metric education materials was developed over a five-year period by the Science and Mathematics Teaching Center (SMTC) at the University of Wyoming. The complete package of materials (described below under WHAT?) is one aspect of the SMTC's response to the inservice needs of classroom teachers and inservice leaders in Colorado and Wyoming. Modification of the materials during the five-year period was based upon (1) the comments of the inservice leaders who used the materials with teachers, (2) classroom teachers who adapted the materials for use with children and (3) SMTC faculty who used the materials to train teacher leaders. As of January of 1977, the SMTC had trained 83 metric inservice leaders; these leaders had conducted inservice classes in 59 communities in Colorado and Wyoming. The materials also have been used with teachers and children in seven other states.

The materials are now part of a teacher-leader training package used by the Quadra-State Metric Consortium, a four-state (Idaho, Montana, Utah, Wyoming) metric education project funded by the United States Office of Education. In using these materials the Consortium has, in effect, accepted the general philosophy as well as the specific technical and educational decisions which are expressed therein. Thus, these materials reflect a major metric inservice effort being conducted throughout the four-state region.

WHAT'S ON THE MENU?

A METRIC SMORGASBORD is comprised of three kinds of metric education materials: instructional activities, teacher support materials and construction activities. The nature and quantity of each of these materials is described below.

Instructional Activities. This is comprised of 115 color-coded activities divided among length (26), mass (21), volume (24), area (23) and temperature (21). Designed as a "starter set," these activities have been used extensively with students in grades 3-8. They were intended to suggest types of measurement activities of interest; teachers usually modify them to fit the students with whom they're working and use them to develop activities of their own. These are not paper-and-pencil tasks. They are experiences in measurement directed at helping students (and teachers) to think and estimate in metric units. A few are extended projects. Each indicates the purpose of the activity, gives directions for the student and describes the materials required for the activity. Most contain notes for the teacher (which have been placed at the bottom where they may be cut off).

Teacher Support Materials. This collection of materials have been developed in response to teacher requests. It includes such items as (1) excerpts from the Metric Conversion Act of 1975, (2) a simplified discussion of the units, symbols and conventions of use of the International System of Units (i.e., the metric system), (3) a one-page reference sheet of those units of length, area, volume and mass which are to be taught to all students, (4) a paper suggesting how to budget for metric education and (5) a set of sample lab and paper-and-pencil metric tests.

Construction Activities. Called make-it-and-take-it activities by teacher leaders who conduct metric inservice workshops for the Center, these 14 activities describe physical materials and games to be constructed for classroom use.

ARE "DOGGIE BAGS" AVAILABLE?

Indeed, you can take samples of the SMORGASBORD to share with others since the Center will permit reproduction of any or all of these materials if requested in writing. For specifics regarding permission, see the cover of the SMORGASBORD or contact Bob Kansky, Box 3992 University Station, Laramie, WY 82071 (Phone: 307-766-6381).

FIRST COURSE:

INSTRUCTIONAL ACTIVITIES

SAME-OF-LENGTHS

TASK: To become familiar with the length of a metre

ACTIVITY: Use the metre stick to find 3 things in the room with a length of about one metre.

MATERIALS: A metre stick

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METRE STRIDE

TASK: To practice making a 1-metre stride

ACTIVITY: A. A "walking course" has been marked off on the floor. The pieces of masking tape in the course are one metre apart.

Practice walking the course until you have the "feel" of a stride which is one metre long. Test yourself by walking the course with your eyes closed!

B. As soon as you can pass the test of Part A, do the TREASURE HUNT exercise.

MATERIALS: Distances marked off 1 metre apart on a floor.

* *

NOTE: This activity is to provide facility in estimating shorter distances. Activity "PACING METRES" is to be used to gain facility if long distances are to be paced and the distance estimated.

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TREASURE HUNT

TASK: To practice using your personal examples of a metre

ACTIVITY:
1. Before doing this activity, do the activity in which you practice making a one-metre stride.
2. Find the yellow cross; stand with that cross at your feet and face the sheet of colored paper which is hanging on the wall.
3. Follow the directions on your copy of the TREASURE HUNT worksheet.
4. DO NOT USE ANY MEASURING INSTRUMENTS (except your bod) IN DOING THIS EXERCISE.
5. Answers are on the back of this sheet. DO NOT look until you have finished the "HUNT."

MATERIALS: Direction sheet for "HUNT"
Crosses set up in appropriate places
Piece of paper
Compass (optional) -- see (b) of NOTES

* *

NOTES: (a) A sample direction sheet for a "hunt" is attached for format purposes only. The actual distances and directions will depend upon local conditions.

(b) You can make the hunt more involved by replacing 'left,' 'right,' 'forward' and 'backward' by 'north,' 'southwest,' etc.

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TREASURE HUNT MAP DIRECTIONS

1. Stand with the yellow cross between your toes and face the sheet of paper hanging on the wall.

2. Go 1 metre forward
   4 metres left
   3 metres left
   3 metres right
   2 metres right
   11 metres left
   8 metres right
   4 metres left
   11 metres left

   SAMPLE ONLY!

   What is the color of the cross nearest your feet? _____

3. Stand with the cross you just found between your toes and face the wall of this room that has windows in it.

4. Go 4 metres right
   3 metres right
   12 metres right
   3 metres right
   3 metres backwards (Don't turn around! Just back up.)
   8 metres right
   3 metres left
   3 metres left

   Describe the cross nearest your feet. _____

Use no "commercial" measuring instruments. Estimate all lengths using what you've learned about lengths on your body.

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TRUNDLING ALONG

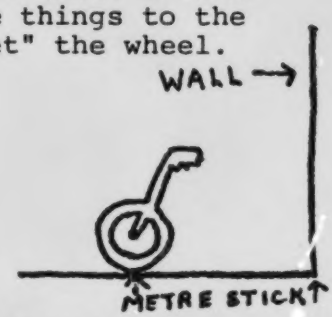
Task: To learn to use the trundle wheel to measure large objects to the nearest metre

Activity: "To trundle" means "to roll along." The trundle wheel you have been given is rolled along to find the measure of large objects such as the length of a field or the width of a room. Let's learn how it works.

A. 1) Place the wheel on its side on the floor.
   2) Wrap the tape around the outside of the wheel. How far is it around the outside of the wheel?

B. The wheel moves one metre every time it makes a full turn. There is an easy way to measure things to the nearest metre when you know how to "set" the wheel.

1. Roll the wheel along the floor until it makes a loud "click."
2. Stop as soon as you hear the click.
3. Pull the wheel back towards you until it will no longer turn. This is called its "jammed position."
4. While keeping the wheel "jammed," position it so that the START arrow points to the floor.
5. The wheel is now "set."
6. Now roll the wheel forward. Each time it clicks, you will have moved one metre.



Starting in a corner (or from any wall) causes a special problem since the wall prevents placing the START position right at the edge of the floor. (Try it.) To overcome this, use a metr stick to start the wheel away from the wall. Be sure the students include that first metre in the total length.

C. 1) "Set" the wheel in the corner of your classroom and measure the length of your room to the nearest metre - that is, to the nearest full turn of the wheel.
   2) Find the width of your room to the nearest metre.

D. Find the height of your room to the nearest metre.

E. Find the length of the hallway outside this room to the nearest metre.

MATERIALS: Trundle Wheel
Two-edged cloth tape
A metre stick

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PACING METERS

Task: To learn how many paces one makes in walking 10 metres.

Activity: A. The distance marked off in the hall is 10 metres.

1. Walk this distance at your regular pace. How many steps did you take?_____
2. Now repeat this two more times and record the results._____

   _____
3. What is the average of your three answers?_____
4. How long is one of your average paces? _____

B. Pace off some unknown distance.

1. How many metres is this according to your pace?

   _____
2. Now measure this distance using the 1-metre measuring wheel._____
3. If your estimate is off by more than 3 metres, repeat this exercise.

Materials: Masking tape
1-metre measuring wheel

* *

Note: This activity is designed for persons to obtain the ability to estimate long distances by pacing. Activity "METRE STRIDE" is designed so people can estimate short distances.

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HALLS OF METRES

Task: To provide practice in estimating lengths

Activity: 1. Estimate some lengths as indicated by your instructor.
2. Check your estimate using the trundle wheel or by pacing.

Materials: Trundle wheels
Lengths to estimate

* *

Note: Lengths to be estimated might be the length of a hall, playground, lunchroom, etc. If this activity follows "PACING METRES" it will reinforce the desired result of that activity.

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I'LL BE DECIMETRED

TASK: To find "personal" examples of a decimetre

ACTIVITY: You will often need to measure objects to the nearest decimetre when you do not have any measuring sticks or tapes available. For this reason, you should know how to use your body to measure things in decimetres.

A. Using the stick or strip, find at least one way to use your hand to estimate a decimetre length. Make a note of how you do it.

B. Find several other ways to use your body to estimate a decimetre length. Make a note describing each way.

C. Suppose you needed to measure something round (like a ball or the trunk of a small tree). Find a way to use your body to estimate that measure in decimetres. Make a note of how to do it.

EXTENSION:

1. Find distances on your body which are about 2 decimetres in length.
2. Find some which are about 5 decimetres in length.
3. Find some which are 10 decimetres in length.
4. Find some which are about 1 metre in length. (Think.)

MATERIALS: A decimetre-band stick
Strips of paper, each one decimetre in length

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AIR METRIC

TASK: To use paper to provide for length measurement.

ACTIVITY:

1. With the materials provided, construct a paper airplane.
2. Go into the hall, throw the paper airplane and record the distance travelled.
3. Repeat this 4 times, then find the average distance travelled; record this.
4. Your average wasn't too hot, so crumble the airplane into a ball and throw it as far as you can and measure the distance thrown. Throw it 4 more times and compute an average.
5. How does the average from 3 compare to the average for 4?

MATERIALS: Paper
Paper clips
Tape
Trundle wheel

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METRIC ME

TASK: To find useful personal measurements

ACTIVITY: The purchase of such items as clothing requires the knowledge of certain body measurements. This is particularly true for men since they select ready-made clothing by giving specific body measurements; women often select by size (a pattern with a range of body measurements) which partially explains their need to try on dresses, suits and what not in order to make sure of the fit.

Each of several useful personal measurements is listed below along with an indication of whether that measurement is of particular interest to women (W) or men (M). With the help of a partner (and you will need one), get those measurements of use to you. Measurements should be to the nearest centimetre.

neck	M
chest or bust	W M
shoulders	M
waist	W M
hips	W
sleeve	M
inseam	M
total height	W M
ski length	W M

MATERIALS: Copies of "Personal Measurements"
Height chart
Some centimetre tape measures

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PERSONAL MEASUREMENTS

(in centimetres)

	MEN	WOMEN
NECK		
CHEST		
BUST		
[1]SHOULDERS		
WAIST		
HIPS		
[2]SLEEVE		
INSEAM		
*TOTAL HEIGHT		
[3]*SKI LENGTH		

[1]Measure from shoulder to shoulder across the back (with your arms at your sides).

[2]Extend the arm forward. Measure along the top of the arm from the bone in the shoulder to the bone in the wrist.

[3]Hold your arm straight up and bend your hand at the wrist. Measure from the wrist to the floor.

*Use the height chart (on the wall) to find this measure.

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METRIC BODY

TASK: To use your body to find the measure of objects to the nearest metre

ACTIVITY:

A. Since you are to use only your body in this exercise, you must know some things about your measurements. Thus, before doing this exercise, you should do the exercise entitled "METRIC ME." If you haven't done that exercise, find it and do it now.

B. There are five figures drawn with tape (3 on the walls and 2 on the floor) near this table. With the help of what you know about lengths on your body, find the perimeter-measure of each object to the nearest metre.

MATERIALS: Masking tape
5 figures drawn

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A CENTIMETRE OF YOUR OWN

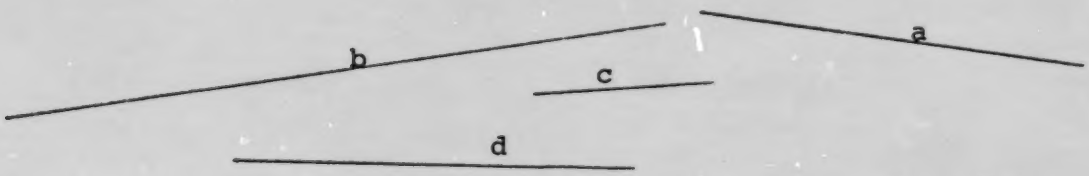
TASK: To find "personal" examples of a centimetre.

ACTIVITY: To measure small things, you have used a measuring stick or tape which has been divided into small bands 1 centimetre long. The ruler you use in this activity is divided that way.

Sometimes you will need to measure something small to the nearest centimetre but you will not have a measuring stick available. In this activity, you will find ways to use your body to estimate the length of things in centimetres.

A. With the help of the ruler, find ways to use your hands to estimate a length of one centimetre. Make notes of how to do this.

B. 1. Using your hands, but NOT the ruler, find the length of each of the four line segments below:



2. Now use the plastic measuring stick to check the answers you just got.

3. If the measurements in Part 2 do not agree with those you got in Part 1, find a better estimate for one centimetre on your hand.

MATERIALS: Ruler divided into centimetre bands.

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GIVING METRICS A HAND

TASK: To learn to use your hand as a measuring instrument

ACTIVITY: A. Using a centimetre ruler or centimetre tape, measure (to the nearest centimetre) and record the following information about your right hand.

1. Find the length of the thumb and each finger (index, middle, ring, and pinky).
2. Find the width of your palm.

3. Stretch your hand and find its greatest span.

4. Find the distance indicated below.

5. Spread your fingers and place your hand (palm down) on a sheet of paper. Beginning at the wrist bone below your thumb, trace the outline of your hand, ending at the other side of the wrist. Find the length of that tracing.

B. Repeat Parts 1 - 5 for your left hand and compare.

MATERIALS: A centimetre tape measure
A centimetre ruler
Paper

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I'M LENGTH TO YOU

TASK: To find parts of your body which have the same length.

ACTIVITY:

A. 1. Cut a piece of string the same length as the circumference of your ankle.

2. Find other parts of your body that have the same length as the circumference of your ankle.

B. Repeat (A.) above using the length of the circumference of your neck.

C. Find other parts of your body that are the same length.

MATERIALS: String
Scissors

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GROUP HIGH

TASK: To estimate the heights of persons (to within 3 centimetres)

ACTIVITY:

A. To do this activity, you must know your own height to the nearest centimetre. If you don't, find out before going on. (Do this privately. Throughout this activity, never tell anyone your exact height.)

B. Form groups of 6 to 8 persons.

C. 1) Write your name at the top of a piece of paper.
2) Below your name, write the name of each other person in the group.
3) Beside the name of each other person (but not your name) write your estimate of his height to the nearest centimetre. (In making your estimate, you can have any person stand up. You can stand next to him or in any other way use your own body to help you to estimate his height.)

D. 1) When each person in the group has written down an estimate of the height of each other person, the group should sit in a circle.
2) Hand your list of estimates to the person at your right.
3) On the list you've just been handed, there should be an estimate of your height. If that estimate is more than 3 centimetres too big or 3 centimetres too small, put an 'X' next to it.
4) As you check each paper, pass it to your right until you have checked everybody's estimate of your height.

E. 1) Get back your own list of estimates.
2) Write new estimates for any you missed and pass them to the persons involved.
3) Keep going until you have a good estimate (i.e., you get no 'X') for each person in the group.

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TRUNDLE-TRUNDLE: WHERE THE _ _ _ _ DO WE TRUNDLE?

TASK: To measure large distances using a trundle wheel

ACTIVITY:

A. Find a partner.

B. Select a sealed map.

C. Using a trundle wheel, find the length (to the nearest metre) of each path that has been indicated on your map with green ink.

MATERIALS: Several "local" maps marked with green ink and sealed with tape.
Trundle wheels

* *

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METRIC FOOT

TASK: Estimate your shoe size

ACTIVITY:
1) Find your approximate shoe size measuring from the tip of your shoe to the tip of your heel.
2) Find the width of your shoe by measuring the widest part of your shoe from side to side.
3) Try taking your shoe off and repeating 1 and 2.
4) What is the length of the longest toe on your foot?

MATERIALS: Some centimetre tape measures
Paper

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ANT CURVES

TASK: To estimate the length of curved lines

ACTIVITY: The map shows the homes and neighborhood of three ants: Alphonse, Boris and Clyde.

The paths between the ants' homes go around rocks, clumps of grass, and the homes of other insects. The ants always travel along these paths when visiting one another.

A. 1. Estimate how far, to the nearest centimetre, Alphonse travels in going to visit Boris.

2. Estimate the distance Clyde travels to visit Alphonse.

3. Estimate the distance Boris travels to visit Clyde.

B. When you have finished Exercise A, use the materials provided to check your answer.

MATERIALS: Pieces of string, wire, or light-pull chain.
"Map" of an ant neighborhood
Some centimetre tape measures

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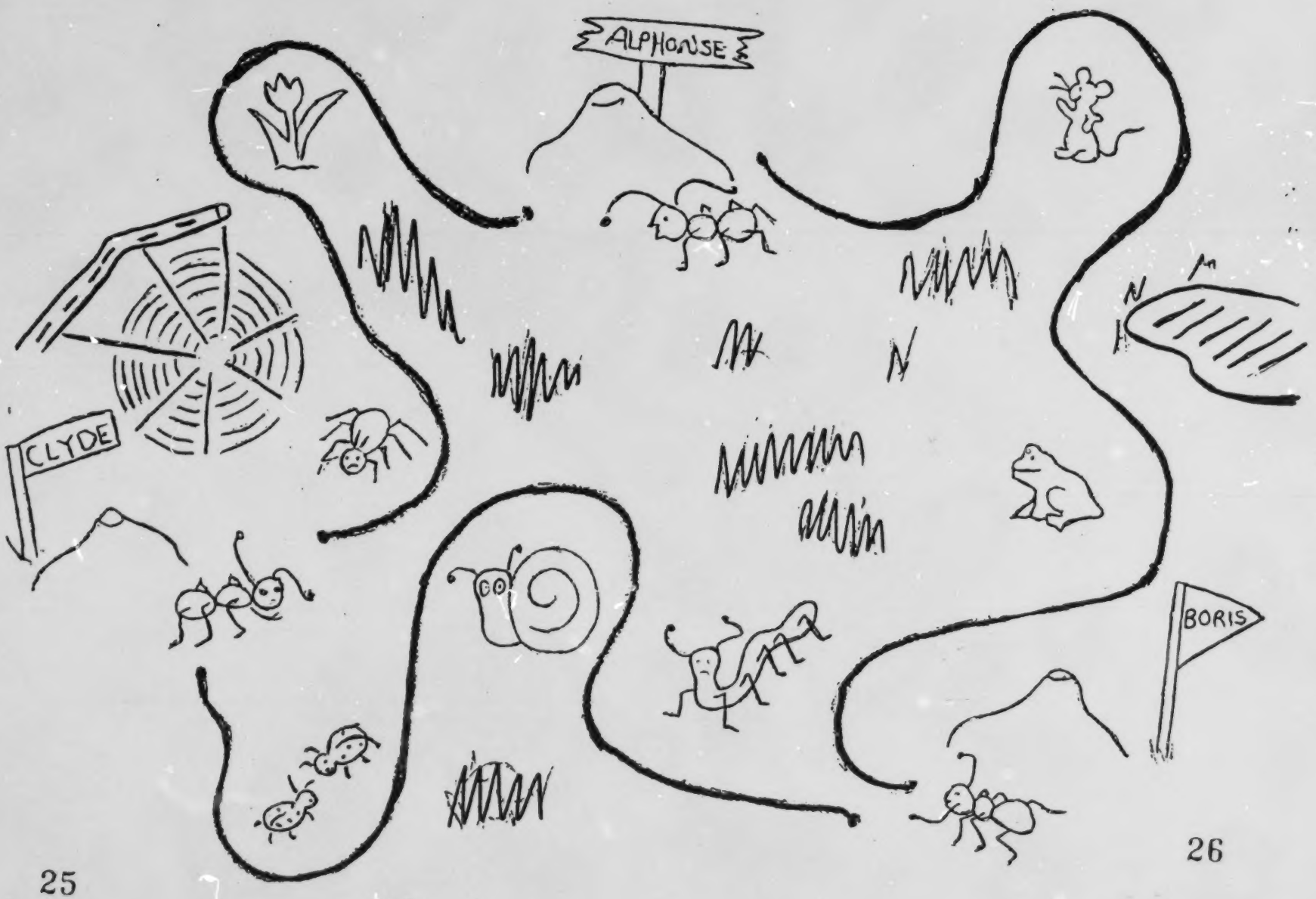
ANT CURVES WORKSHEET



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HOW LENGTHY ARE YOU?

TASK: To estimate lengths of segments

ACTIVITY:

1. There are ten distances marked on the board.
2. Estimate these distances to within 4 cm.
3. When you think you know all the distances, check your answers. If you are wrong, get a trundle wheel and find the height of this building. Good luck.
4. Now estimate the length and width of this paper. If you are within 2 cm then go to number 5.
5. This is the hardest distance to determine, so be very careful and as accurate as possible. You must measure the distance from here to where you live. When you are through you can check your answer with the one on the back of this sheet.

MATERIALS: Ten distances marked on a board
Trundle wheel

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GOLDEN CURVES

TASK: To measure curves to the nearest centimetre

ACTIVITY: You have been given pictures of an artist's design for several pieces of jewelry. The jewelry is to be made from a gold wire which costs 32¢ per centimetre. Find the cost of the gold wire required for each design.

MATERIALS: Copies of GOLDEN CURVES WORKSHEET
String
Rulers
Measuring tapes
Some decimetre trundle wheels (if you've made them)

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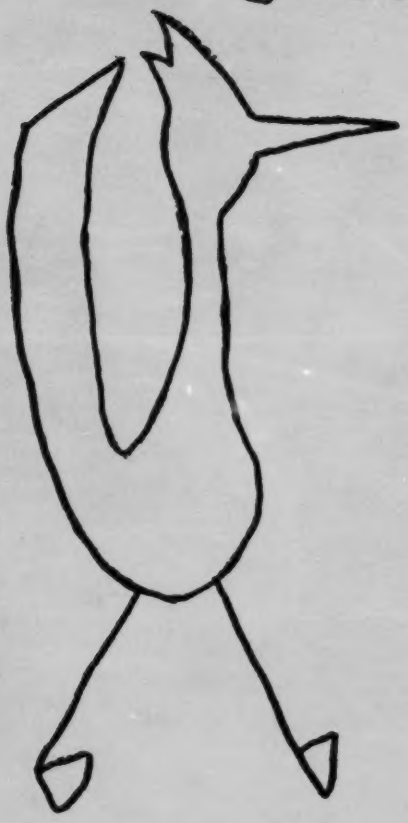
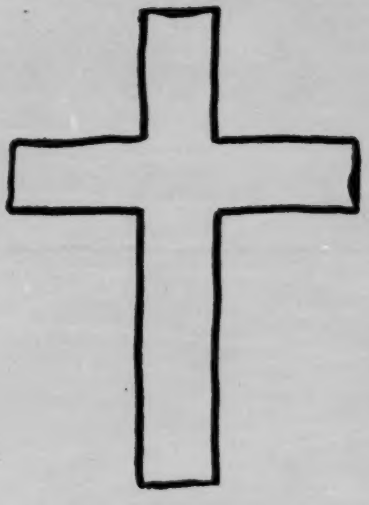
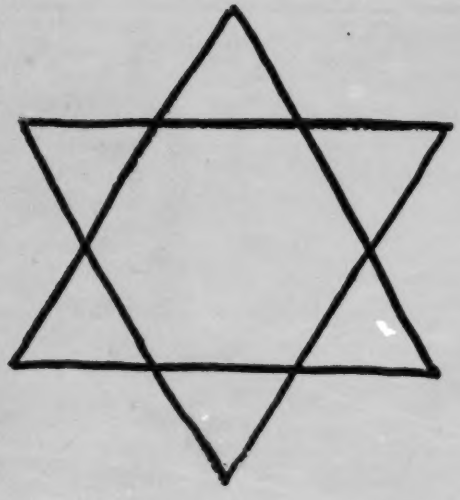
Golden Curves Worksheet







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I, SPY

TASK: To describe yourself to a stranger by using measures of length, volume and mass

ACTIVITY: You're a secret agent. Although your assignment requires that you wear a disguise (a wig, colored contact lenses, glitter clothes and a false nose), you need to be able to identify yourself by description to another agent without speaking or gesturing. (Hence, no password or "high sign" is possible.) Since you don't know exactly when the contact is going to be made, you can't be sure of what you'll be wearing.

You and your chief agree that the other agent will have to identify you from a description which gives ten personal measures.

A. 1. Don't talk to anyone about the measures that you take during this activity!

2. On a separate sheet of paper, record the following personal measures:
   - height
   - mass
   - waist size
   - neck size
   - foot size (length)

3. Also record five other measures that would help another agent identify you.

4. Turn in your description to the chief (teacher) before anyone else sees it.

B. Later (perhaps tomorrow) you'll be given the description of several agents. Your job will be to identify each.

VARIATIONS: I. Pair off with another person. Write that person's description using no measuring instruments and hand it in.

II. Exchange descriptions with another class. Meet as a group and try to identify members of the other class from their descriptions.

MATERIALS: Tape measures
Some metre sticks
Personal (bathroom) scale

* *

NOTES: (a) Read the descriptions written for Part A; remove inappropriate items or "dead giveways." Compile a set of descriptions and reproduce them on a worksheet like the sample attached. In doing so, randomly delete a few class members from the list and add a description of yourself. Also add a description such as Spy 3 on the sample -- a weird character -- to test everyone's ability to recognize the absurdity of the description.

(b) In doing Variation II, break the classes into paired subgroups of 12 - 16 persons.

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SAMPLE

I, SPY

(IDENTIFYING MEASUREMENTS)

Fill in the name of each agent described. You may (within the limits of Wyoming propriety) check measurements using personal referents, but you may not use formal measuring instruments.

Make no verbal declarations; ask no questions, please.

Go.

Spy 1: _____

Height — 185 centimetres
Mass — 80.5 kilograms
Waist size — 91 centimetres
Neck size — 40 centimetres
Foot size — 29 centimetres
Wrist — 19 centimetres
Tip of middle finger to mid-chest (with arm extended) — 97 centimetres
Wart on right bicep to mid arm — 4 centimetres
Width of ring — 6 millimetres
Length of my lifeline on right palm — 7.5 centimetres

Spy 2: _____

Height — 177 centimetres
Mass — 86 kilograms
Waist size — 99 centimetres
Neck size — 43 centimetres
Foot size — 30 centimetres
Index finger (width) — 2 centimetres
Nose (from cheek to cheek) — 7.5 centimetres
Belly extended — 107 centimetres
Thigh — 57 centimetres
Head — 59 centimetres

Spy 3: _____

Height — 16 decimetres
Mass — 83 kilograms
Waist size — 90 centimetres
Neck size — 48 centimetres
Foot size — 32 centimetres
Arm length (shoulder to tip of middle finger) — 91 centimetres
Hips — 114 centimetres
Bicep — 53 centimetres
Volume of mouth (closed) — 45 millilitres
Longest eyelash — 1.5 centimetres

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CENTIMETRE GUESS-AND-CHECK

TASK: To estimate (and check) the measurements of objects to the nearest centimetre

ACTIVITY: A. Pick up a copy of the list of objects that are in the box. Follow the directions on that sheet.

B. Please RETURN ALL OBJECTS TO THE BOX before going on.

MATERIALS: Assorted objects (some round)
List of objects
A centimetre ruler
A centimetre tape
String

* *

NOTES: (a) Include objects like a pencil, belt, orange, piece of key chain, key ring, quarter, roll of tape, table knife, etc. A sample list is attached.

(b) This exercise should be repeated now and again using a different collection of objects.

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CENTIMETRE GUESS-AND-CHECK

Below is a list of the objects in the box. For each object, make an estimate (in centimetres) of each measure indicated.

After you have estimated each measure, use any of the measuring instruments to check your estimates. Record the actual measures.

THINGS TO BE MEASURED	ESTIMATE	ACTUAL MEASURE
1. Belt -- length Belt -- width		
2. Index card -- length Index card -- width		
3. Pencil -- length		
4. Golf tee -- length		
5. Ball -- circumference		
6. Yellow cube -- edge length		
7. Typing paper -- length Typing paper - width		
8. Glass -- height Glass -- width of top Glass -- circumference (top) Glass -- width of bottom Glass -- circumference (bottom)		
9. Popsicle stick -- length Popsicle stick -- width		

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A-MAZE-ING

TASK: To get through a maze by estimating distances in centimetres

ACTIVITY: Pick up a copy of the METRIC MAZE and find your way through it by following the directions given below.

Although there are many paths through the maze, there is only one correct one. The correct one is the one which corresponds to the directions given.

A-maze-ing Directions

Begin at Start

Go	4 centimetres	South
	3	East
	8	South
	7	East
	10	North
	5	West
	4	South
	1.5	East

Did you make it? See your teacher for the solution.

VARIATION: Have a group of students use a centimetre ruler to plot new paths through the maze. (Agree on the number of directions to be given.) Have groups exchange directions and, without using rulers, find the new paths.

MATERIALS: Copies of the METRIC MAZE

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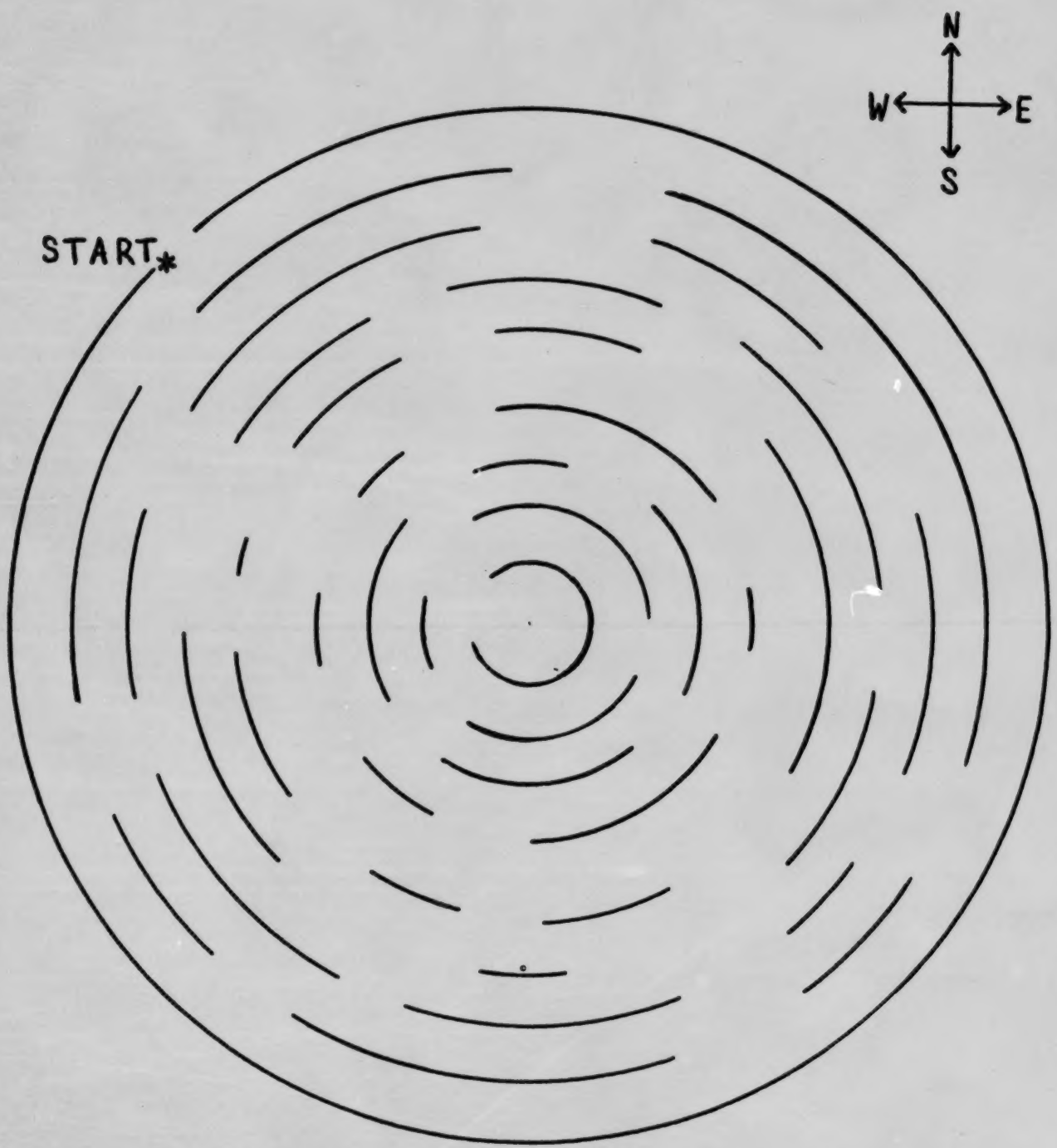
METRIC MAZE

Although there are several paths through this maze, only one is the correct one. To find it, all that you have to do is to follow the directions given and use only <u>your body to make the measurements</u>.



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WHAZIT?

TASK: To describe and identify objects from their measures

ACTIVITY:

A. Several objects have been provided. Working as a group, do the following for each object.

1. Write its name on a piece of paper. (Use a different piece of paper for each object.)
2. Below the object's name, write a description of the object using measures of length, area, volume and mass only! You may not include such things as color, general shape, taste, smell, etc. in your description.
3. Hand in your descriptions to your teacher.

B. You will be given the descriptions of several objects. Working as a group, find each and write its name next to the description.

C. Your group gets 1 point for each object it correctly identifies. Your group also gets 1 point for each object which it described and which another group was able to identify.

VARIATION: Confine the descriptions to just one kind of measure (say, mass).

MATERIALS:
Several objects (6-10) for each group
Measuring tapes
Balance beams and masses
Rulers
Area grids
Volume cylinders

* *

NOTES: Divide the class into groups of about 4 persons to do this exercise. Have each group work in a location where it can't observe any other group. Give each group a box or bag containing 6-10 items to be measured. A few groups should have an item or two in common. Collect the descriptions; cut off the name of the object; give the name and corresponding description a common code number so that you can later match them.

On the next day, give each group's descriptions to some other group. Have all objects lying (mixed) on one table. Give a class a limited time (20 minutes or so) to identify the objects from their descriptions. Reveal the correct answers; score and discuss.

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SPARE ROOM

Task: To duplicate a room

Activity: Your job is to give a complete description of this room (exclusive of furniture, lights, decorations, etc.). Your description should be clear enough to allow a builder to build a room just like it. Among the things you should do are the following.

A. 1) Make a sketch of the floor and of each wall of the room.
   2) Give the dimensions of the floor and each wall.

B. If a wall has a door or window, you should -
   1) Give the measurements of each door or window.
   2) Give measurements which tell exactly where on the wall the door or windows are located.

Variations:

a) Use the information gathered above to make a scaled drawing of the room.
b) Make a scaled drawing of the outline of your school building(s), athletic fields, etc.

Materials: Trundle Wheels
Several metre sticks
Measuring tapes

* *

Notes:

a) Break class into groups of about 3-4 persons.
b) Consider doing several rooms.

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MINI-LENGTH

TASK: To work with very small lengths

ACTIVITY: A. Using the cards and a ruler, find the thickness of one playing card.

B. Based upon your results in A, predict the thickness of 40 cards. Verify using the ruler. How good was your estimate in A?

MATERIALS: Playing cards
Ruler
Calculator

* *

NOTE: Results in A will usually be different depending upon the method of solution. However, the idea that the more cards you originally use to get your first estimate provides the best estimate, should be obtained.

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ROAMING WYOMING

TASK: To find distances, in kilometres, between towns in Wyoming

ACTIVITY: A. Find the towns of Cody and Burlington on the map of Wyoming that you've been given.

The distance--as the crow flies--from Cody to Burlington is 50 kilometres.

Using the information above and the materials provided, find the distances between the following towns (to the nearest 10 kilometres).

1. Spotted Horse and Midwest
2. Laramie and Cheyenne
3. Lusk and Yod
4. Evanston and Lander
5. Rawlins and Laramie
6. Sundance and Moorcroft
7. Casper and Recluse

B. Using your home town (or Laramie) as the "center of the state," find the distances--as the crow flies--from that "center" to several other major towns in the state. Be certain, of course, to include the distance to Lightning Flat.

C. Find two towns which are just about 100 kilometres apart. About 300 kilometres apart. About 500 kilometres apart.

D. Find the "dimensions" of Wyoming in kilometres.

MATERIALS: Map of Wyoming
String
Strips of paper or tag board

* *

NOTE: The usual road map may be a bit overpowering for young students. You may wish to make a simplified map by tracing the outline on butcher paper and marking "selected" cities.

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WHICH-A-MASS

TASK: To compare and order the masses of several objects

ACTIVITY:

A. Six objects (A, B, C, D, E and F) are wrapped in sheets of yellow paper. Using only your hands, order the objects from the object of least mass to the object of greatest mass. List the names (letters) of the objects which correspond to that ordering.

B. Use the balance to check the ordering that you gave in Part A. If you made any errors, use the balance to produce a correct ordering.

C. Please return the six objects to their container when you are through with them.

D. What is the least number of balancings needed to determine the correct order?

E. Answer is on the back.

MATERIALS: A balance
Six small objects, each wrapped in a sheet of yellow paper, labeled A - F.

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FRUITY STEW

TASK: To order and obtain the masses of common fruits and vegetables

ACTIVITY:

A. Using the vegetables and fruits provided, estimate their masses with your hands and arrange them in order from least to greatest mass.

B. Using the balance, by comparing them with each other, verify the arrangement you decided upon in part A.

C. Using the balance and the masses provided, check your estimate of the mass of each vegetable or fruit.

MATERIALS: Vegetables (potato, carrot, tomato, etc.) and fruit (banana, orange, peach, etc.)
Balance and masses

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MASS A-PAIRING

TASK: To compare the masses of pairs of objects by estimating (and to check those estimates with a balance)

ACTIVITY:

A. 1. Pick up Item A with one hand and Item B with the other.

Using your arms like a balance, estimate which item has the greater mass. Record the letter of the greatest mass in the space provided in the chart.

2. Repeat the estimating procedure for each pair of items listed in the chart.

B. Now check the estimates of Part A as follows:

1. Use the balance to compare the masses of each pairing listed in the chart.
2. Record the letter of the item with the heavier mass in the space provided.

Items to Compare	ITEMS WITH THE GREATER MASS	
	Your estimate	According to the balance
A and B		
B and C		
A and C		
C and D		
D and E		
C and E		
E and F		
A and F		
B and E		
C and F		

MATERIALS: Six items marked A, B, C, D, E, F

A balance

* *

NOTES: (a) Choose the six items so that some pairs differ greatly in mass (50 grams or more), some pairs are close (10 grams or less) and, perhaps, two items have the same mass.

(b) Repeat for new sets of items.

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AMASSING MASS

TASK: To keep a record of mass changes in class members during the year

ACTIVITY: This is a long-term activity. Once organized, it should be continued for several months.

A. To begin:

1. Each class member should find his mass (in kilograms). At the time this is done, be certain to record the date, day of the week and time of day (early morning, just before lunch, right after lunch, just before going home, etc.).
2. What relation, if any, would the facts you recorded above have to your mass?

B. To continue:

1. Decide upon a regular schedule for taking and recording your mass. (Recommendation: Do it at least once every two weeks.)
2. Be certain to consider the things discussed in Part A(2) when you plan that schedule.
3. Decide how you will keep a record of your mass so that it is easy to see any changes that take place during the year. Your teacher may have some suggestions.
4. Decide upon a way to remind yourself to stick to the schedule you have planned. Working with others may help.
5. Carry out the plan you developed in 1-4 above.

MATERIALS: Personal scale
Calendar
Other materials identified in Part B (graph paper, etc.)

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MASSTASTIC

TASK: To estimate and find the masses of objects using a bathroom scale

ACTIVITY:

A. First, stand on the scale and record your mass in kilograms.

B. Next, estimate the mass of the stack of books; then check your estimate by holding the stack and standing on the scale. Now you know the mass of the stack of books. Estimate the mass of the other materials provided by the instructor. After you have estimated, check your answer as you did for the stack of books.

MATERIALS: Bathroom scale
Materials (bucket of water, can of salt, partner(?), chair, small table, etc.)

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MONEY MASSES

TASK: To learn the mass of each U. S. coin.

ACTIVITY: *A. Find and record the mass of each U.S. coin. The plastic cubes provided for this activity have a mass of one gram each.

B. Use the information that you gathered in Part A (as well as the balance and plastic cubes) to help you answer the following questions.

1. Which coin has the greatest mass? Which has the least mass?
2. In terms of purchasing power, a nickel is equivalent to five pennies. Is the mass of a nickel equivalent to the mass of five pennies?
3. Which of the following are equivalent in terms of mass?

   a. A quarter is equivalent to five nickels.
   b. A quarter is equivalent to two dimes and a nickel.
   c. A half dollar is equivalent to two quarters.
   d. A dime is equivalent to two nickels.
   e. A half dollar is equivalent to five dimes.
   f. A quarter is equivalent to a nickel and two pennies.

C. Suppose that the U. S. coins in Leander's pocket have a total mass of 15 grams. Tell what coins he might have. (Is there more than one possibility?)

* Keep a record of what you learn; you'll need the information to do other exercises.

MATERIALS:
A balance
Some one-gram masses (about 25)
5 pennies
5 nickels
5 dimes
2 quarters
1 half dollar

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MONEY'S WORTH

TASK: To use U. S. coins to find the mass (in grams) of each of several small objects.

ACTIVITY: In the activity MONEY MASSES you found the mass, in grams, of each U. S. coin. Using a balance, some coins, and the information you gathered in that earlier activity, find the mass, in grams, of each of the small objects given.

Keep a record of your results.

MATERIALS:
A balance
Several objects with masses ranging from 5 grams to 100 grams
15 pennies
5 nickels
5 dimes
2 quarters
2 half dollars

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BALANCING THE BUDGET IN YKSNAK

TASK: To use a balance to compute value from mass

ACTIVITY: A. In some countries, people used to pay their taxes with precious goods such as silver, gold, salt, coconut meat, and spices. Each year there would be a tax-paying ceremony at which the king of the country would sit in one pan of a large balance (just a large version of the one on this table); his subjects would place the required precious goods in the other pan until the two masses balanced.

1. Pretend that the little clay king is the king of a country (Yksnak) which pays its taxes in copper (pennies). How much would the king be worth?
2. Suppose that this king decided to make his subjects pay their taxes by matching his mass in dimes. How much would he be worth then?
3. How much would the king be worth if his subjects paid their taxes using nickels?

B. In 1974, a certain king required that his subjects match his mass using dimes. In 1975, he required them to use quarters; in 1976 he required half dollars.

1. In 1974, his mass brought him a tax income of $40,000. If the king neither gained nor lost mass for the next two years, how much did he receive each year?
2. What relationships exist among the masses of dimes, quarters and half dollars?

MATERIALS: 45-gram king (see note below)
A balance
20 pennies
10 nickels
20 dimes
4 quarters
2 half dollars

* *

NOTE: You can fashion his body from clay, scepter from a toothpick, crown from a bottle cap, and cape from a bit of cotton.

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MASS BY GRAMS

TASK: To use one-gram masses to find the masses of several objects.

ACTIVITY: A. The masses of relatively small objects are reported in grams. Each of the plastic cubes used in this exercise has a mass of one gram.

1. Make a list of the objects in the box.
2. Using the balance and the gram-masses, find the mass of each object and record it on your list. (After you have done a few objects, you might try your hand at estimating the mass of the object before using the balance and cubes to find it.)

B. Please return all objects to the box when you are done.

MATERIALS: About 50 of the one-gram plastic cubes
A balance
Some small objects in a box (do not exceed 50 grams)

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MASS, OH MASS

TASK: To locate references for masses of 50 - 100 grams

ACTIVITY: A. Search for and identify 5 objects that have a mass between 50 and 100 grams.

B. Check and record the masses of the objects found.

MATERIALS: Balance and masses

* *

NOTES: (a) Hopefully each person will be able to find at least one thing that fits the 50 - 100 gram category that is quite familiar to him or her (watch, lipstick, etc.).

(b) This should be repeated, with the task being to find objects in the 1 - 5 gram range, the 400 - 600 gram range, or the 900 - 1000 gram range.

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YOU BET YOUR MASS

TASK: To estimate the body masses of other persons

ACTIVITY:

A. Each person is to write his mass (in kilograms) on a sheet of paper and hang it around his neck. The numerals should be large enough to be read from across the room. Turn the paper so that the writing cannot be seen.

B. Have two "captains" select teams. Each team should form a line in order of height, beginning with the shortest team member. The team with the shortest class member plays first.

C. The first persons in each line face each other; the first person to play declares the mass of the person he is facing.

1. If the guess is within 2 kilograms of the correct mass, the team doing the estimating gets 3 points and both the guesser and the guessee move to the ends of their respective lines.
2. If the guess is not within 2 kilograms of the correct mass, the team with the member whose mass was estimated gets 1 point; only the guesser moves to the end of his line.
3. In either case, the opportunity to guess a mass moves to the other team.
4. At any time, a player may ask a player on the opposite team to reveal his mass. In such a case, the person making the request loses his turn and the opposing team is awarded 3 points.

D. After 15 minutes, reorder the lines in each team by placing team members in alphabetical order. Play for another 15 minutes.

E. The winning team is, obviously, the team with the greater number of points.

MATERIALS: Sheets of paper
String

* *

NOTE: This could be played using height (in centimetres or decimetres) rather than mass.

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GOTTA BEEF?

TASK: To learn to cut clay "beef"

ACTIVITY:

A. You can make enough meatloaf to serve 8 persons if you have one kilogram (1000 grams) of ground beef. Pretend that the material that you've been given is a package of ground beef.

1. Roll the beef into one ball.
2. Using the knife, cut off what you think is one kilogram of beef.
3. Using the balance and weights, find the mass of the ball of beef.
4. If you cut less than 900 grams or more than 1,100 grams, your estimate was not very good. Try again!

B. You can make a meatloaf for 4 persons with 500 grams of ground beef.

1. Follow the procedure above to cut 500 grams of beef.
2. If you cut less than 450 grams or more than 550 grams, roll all of the beef together and try again.

MATERIALS:
Clay or "beef glop" as described in Note (b) below.
Knife
Balance and masses
Butcher paper to cover table on which "beef" is to be cut

* *

NOTES:

(a) We feel that this activity is useful, even if clay and beef do not have the same volume per mass.

(b) Recipe for "beef glop:" Less difficult to handle than clay, this mixture will last for some time if sealed in a plastic bag. Refrigeration is nice but not necessary.

To make about two kilograms of beef glop, mix:

1000 millilitres flour
500 millilitres salt
500 millilitres water

When thoroughly mixed, add:

30 millilitres cooking oil
red food coloring to "taste"

Mix again, adding flour or water as needed to reach desired consistency.

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COMPARABLE MASS

TASK: To compare the masses of pairs of objects

ACTIVITY: A. Find the two objects labeled with the letter A.

1. Write down the names of the two objects
2. Take one object in each hand. Decide which has the greater mass and circle the name of that object.
3. Use the balance to check the decision that you just made.

B. Repeat Part A for the two objects labeled with the letter B, for the two objects labeled with the letter C, etc.

C. Use the materials provided to find the difference in the masses of each pair of objects.

MATERIALS: Balance and masses
Several pairs of objects (two labeled A, two labeled B, etc.) with roughly equivalent masses

* *

NOTE: If the objects are only 10 - 50 grams different in mass, the fact that a person incorrectly estimated which was heavier is not too hard to understand.

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GRAM GUESS-A-MASS

TASK: To estimate and check the masses (in grams) of some familiar objects

ACTIVITY: A. Estimate the mass in grams of each available object. Do not use the balance. The procedure follows:

1. Pick up one of the objects with one of your hands.
2. Pick up weights with the other hand until you think the mass of the weights is the same as the mass of the object.
3. Write down the name of the object and your estimate of its mass in grams.
4. Repeat the above steps for each object.

B. Now use the balance and masses to check each estimate.

MATERIALS: Balance
Set of masses
Some familiar objects (see below)

* * * *

MIX A MASS

TASK: To estimate the mass (in grams) of several objects <u>without</u> using a balance

ACTIVITY: A. Make a list of the objects in the box. For each item on your list, do the following:

1. Hold an object in one hand.
2. With the other hand, pick up metric masses until the masses in your two hands feel "balanced."
3. The sum of the metric masses that you've picked up is your estimate of the mass of the object. Write it down next to the name of that object.
4. Repeat steps 1 - 3 for each object in the box.

B. When you have completed Part A, check your estimate against the answers given on the back of this sheet.

C. <u>Please return the objects to the box when you're done with them</u>.

MATERIALS: A set of metric masses
A box of objects with masses ranging from 50 grams to 1000 grams

* *

NOTE: This is a repeatable exercise. On some days keep the masses of the objects relatively close together (e.g. 50-100 grams, 200 - 300 grams, 500 - 700 grams); occasionally have a collection with a large range (e.g. 50 - 300 grams, 400 - 1000 grams, etc.).

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MASS HYSTERIA

TASK: To find the mass of several items sold in a supermarket.

ACTIVITY:

A. 1. Working in teams of 3 to 6 persons, make a list of items which are used at home and which you think would be measured by mass (rather than length or capacity). List 8 to 10 items for each person on the team.

2. Working alone, or with a partner, go to a supermarket. For each item on your list do the following:

   a. Find out if it is measured in grams. (Look for the phrases "net mass" or "net weight" on the container.) If so, record the mass of the item.

   b. If the item comes in more than one size (as do cans of fruit or bottles of vinegar), record the mass of reach size of item.

   c. Record the price of each item.

B. Compute the cost per gram of each item on the team's list.

C. Working with the other members of your team of 3 to 6 persons, make a chart which tells what you found out about items which are sold by mass (in grams).

EXTENSION: Repeat the above activity after a month has passed. Compare the new results with the old.

MATERIALS: No special materials needed

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MESSY MASS

TASK: To construct a figure and record its mass

ACTIVITY:
A. Using the materials provided, make 4 equilateral triangles

B.
1. Estimate the mass of the figure you made.
2. What is the mass of the sticks alone?
3. Use the balance to see how close you estimated.

MATERIALS:
4 rubber connectors
6 plastic sticks
Balance and masses

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JOLLY GOOD MASS

TASK: To use mass to find how many kernels of popcorn there are in a container

ACTIVITY:

A. You are to first estimate how many kernels of popcorn there are in one gram of popcorn. Check your answer by weighing the kernels.

B.
1. How much would 1000 kernels weigh?
2. How much would one kernel weigh?
3. Estimate how many kernels there are in the container without counting them.

MATERIALS: Balance and masses
Plastic sack of popcorn

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WATER WITCHERY

TASK: To discover a method of finding the mass of an object which floats on water.

ACTIVITY:

A. You've been given several objects and a copy of a WATER MASS CHART. Record the name of each object on the WATER MASS CHART.

B. Using the balance and metric masses, find the mass of each object. Record your findings in the appropriate places in the WATER MASS CHART.

C. Now get the graduated cylinder and fill it to about half full with colored water.

1. Choose an item. Place it in the cylinder and note the increase (in millilitres) of the water level. This is the volume of water displaced by the object.

2. Each millilitre of water has a mass of about one gram. Use this fact to find the mass of the water displaced by the object. Record that finding in the WATER MASS CHART.

3. Repeat the above displacement process for each object.

D. If you have done your work with care, the entries you've made in the WATER MASS CHART should lead you to an important observation. What is that observation?

MATERIALS:
Copies of WATER MASS CHART
A 500-millilitre or 1000-millilitre cylinder graduated in 10-millilitre intervals
Colored water (use food dye)
Paper towels
Balance and masses
Eight objects which will float in water (see below)

* *

NOTES:

(a) For good results, the objects should have masses between 50 grams and 300 grams, should float, should fit easily inside the cylinder, and should have masses which are multiples of 10 grams. (The last condition is because of the limited graduations on the cylinder.)

(b) There are two extra lines in the WATER MASS CHART. Have extra items on hand to test any conjecture made in Part D.

(c) Have students work in pairs.

(d) The next activity would logically be MASSES AFLOAT.

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WATER MASS CHART

	Name of Object	*Mass of Object (in grams)	**Mass of Water (in grams) Displaced by Object
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

* Find by using the balance and masses.

** Find by using the cylinder.

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MASSES AFLOAT

TASK: To find the masses of objects which float

ACTIVITY: In the activity entitled WATER WITCHERY, you should have reached a conclusion like the following:

> The mass of an object which floats in water is equal to the mass of the water displaced by that object.

We also know.

> The mass of one millilitre of water is about one gram.

A. Use the cylinder of water and the two observations in the boxes above to find the mass in grams of each object which floats. (Use the balance and masses only if you feel you'd like to check the results you get by using the cylinder.)

B. Two of the objects you've been given do not float in water. Use these to test the statement:

> The mass of an object which doesn't float in water is equal to the mass of the water displaced by that object.

Is the statement true?

EXTENSION: Suppose you had some objects which float in cooking oil.

1. Is it true that:

> The mass of an object which floats in cooking oil is equal to the mass of the cooking oil displaced by that object.

2. Suppose that a certain object, when placed in cooking oil, floats in the oil and displaces 60 millilitres of oil. What can you say about the mass of that object? What other information (about the oil) would be useful?

MATERIALS:
- A 500-millilitre or 1000-millilitre cylinder graduated in 10-millilitre intervals
- Colored water
- Paper towels
- About 6 - 8 objects that float (see NOTES (a) and (c) of WATER WITCHERY)
- Two items (iron, stone, whatever) which do not float
- Balance and masses (for checking only)

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GREATER GUZZLE

TASK: To compare the volumes of different shaped objects

ACTIVITY:

A. 1. For each pair of objects, estimate which of the two has the greater volume. Write the name (letter) of that object in the space provided on your GREATER GUZZLE WORKSHEET

2. If you think that the two objects of a given pair have the same volume, write "SAME" in the space provided in the chart.

B. Now use containers X and Y, the funnel and the colored water to check the estimates that you made in Part A. Here is how you do it:

1. Put containers X and Y side by side.

2. Pick one of the pairs of different shaped objects and fill each member of the pair with colored water.

3. Pour the water from one member of the pair into container X.

4. Pour the water from the other member of the pair into container Y.

5. In the space provided in the chart, record the name of the object which you found had the greater volume. If you found that they had the same volume write "SAME".

6. Empty containers X and Y. Repeat the five steps above to check each pair of objects.

MATERIALS:
Two containers of same size and shape (i.e., two large juice bottles) labeled X and Y
Several pairs of different shaped objects labeled A_1 and A_2, B_1 and B_2, etc.
Funnel
Container of water
Copies of GREATER GUZZLE WORKSHEET

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GREATER GUZZLE WORKSHEET

Name of Objects	Which has the greater volume?	
	Estimate	Check
A_1 and A_2		
B_1 and B_2		
C_1 and C_2		
D_1 and D_2		
E_1 and E_2		
F_1 and F_2		
G_1 and G_2		
H_1 and H_2		

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A LITRE GUESS

TASK: To estimate and check volumes of one litre and one-half litre.

ACTIVITY:

A. 1. Pour what you think is one litre of water from the filled bucket into the empty bucket.

2. Use the funnel and graduated container to check your estimate.

3. If you missed by 100 millilitres or more, pour all the water back into the first bucket and try again.

4. Keep trying until you miss by less than 100 millilitres on two consecutive pourings.

B. Repeat steps 1 - 4, but this time estimate one-half litre. In this case, you should keep trying until you miss by less than 50 millilitres on two consecutive pourings.

MATERIALS:
Plastic bucket (3 to 5 litre capacity)
Plastic bucket containing water (about 2 to 3 litres total)
Graduated container, one litre capacity
Funnel
Paper towels

* *

NOTE: If the use of water is a problem, substitute sand, salt, grain, kitty litter, etc.

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POUR GUESSES

TASK: To estimate and check volumes of 50, 100, and 250 millilitres

ACTIVITY:

A. 1. Pick a container and pour what you think is 100 millilitres of water into it.

2. Use the funnel and graduated container to check your estimate. Keep trying until you miss by no more than 10 millilitres.

B. Repeat the process of Part A using the other container.

C. Repeat Parts A and B for a volume of 50 millilitres.

D. Repeat Parts A and B for a volume of 250 millilitres. (In this case, keep trying until you miss by at most 25 millilitres.)

MATERIALS: Container of water (colored with a few drops of food coloring)

Two empty containers marked A and B

Funnel

Graduated container (must hold at least 250 millilitres - should be graduated in 10-millilitre intervals)

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SPOON FEEDING

TASK: To find the metric volume (in millilitres) commonly called a "teaspoon" or "tablespoon"

ACTIVITY:

A. 1. Dip up a teaspoon of water. With the help of the funnel, pour the teaspoon of water into the measuring cylinder. What is the volume, in millilitres, of the teaspoon of water?

2. Put 3 level teaspoons of water into the measuring cylinder. What is the volume of 3 teaspoons of water? From the answer you just got for 3 teaspoons of water, what must be the volume of 1 teaspoon of water?

3. Put 10 teaspoons of water in the measuring cylinder. What is the volume of 10 teaspoons? From the answer you just gave, what must be the volume of 1 teaspoon?

B. 1. Put one level tablespoon of water into the measuring cylinder. What is the volume of 3 tablespoons? Based upon the answer you just gave, what must be the volume of one tablespoon?

C. How many teaspoons of water are in a tablespoon of water?

MATERIALS:
Measuring teaspoon
Measuring tablespoon
Measuring cylinder marked in 1-millilitre intervals
Water
Paper towels
Funnel

* *

NOTES:

(a) Although this exercise can be done with something like salt (instead of water), such granular materials tend to "pack down" and give conflicting results.

(b) The work in A.2 and A.3 checks the hard-to-read result in A.1.

(c) The common measuring teaspoon has been designed to have a volume of 5 millilitres; the measuring tablespoon to have a volume of about 15 millilitres.* The measuring spoon found in Similac cans is a 15-millilitre measure.

* It's actually about 14.8 millilitres.

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FULL OF HOT AIR

TASK: To find the volume of air your lungs hold

ACTIVITY: A. Estimate the volume of air your lungs will hold.

B. Check your guess by using the apparatus set up. By blowing into the tube, you will displace water approximately equal to the volume of air in your lungs. When you are ready, take a deep breath and blow slowly and steadily into the tube until you have expended all of your air.

MATERIALS: A twenty-litre or larger polyethylene water jug
About one metre of tubing
Deep sink
Plenty of water

* *

NOTES: To do this exercise:

(a) Fill the jug to the brim. Invert it (neck down) in a large service sink (bath tub, wash tub) of water.

(b) Insert the plastic tube well into the bottle. Carry out Part B of the activity.

(c) Find out what volume of water is required to refill the jug to the brim.

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A LITRE, IN ANY OTHER SHAPE, IS STILL...

TASK: To estimate and check the volumes of containers of several shapes

ACTIVITY: In another activity, a litre is defined as the volume of a cube which measures a decimetre (10 centimetres) along each edge. While this may be a nice picture to keep in mind when thinking about a litre, the litre comes in many shapes. We need to recognize it is its many disguises.

A. Using the materials here, you can construct a cubic decimetre (litre) container.

B. Several labeled containers are displayed here. Using your mental picture of the litre(cube), write down the volume, in litres, of each container.

C. Check the estimates you made in Part B using the salt, funnel, one-litre measure, and scraper (for leveling the salt and scraping away any excess).

MATERIALS: One-litre container
Mats for constructing the cubic decimetre (litre)
Scissors
Tape
Salt, funnel, and scrapers
Several containers whose volumes range from 0.5 litre to 2 litres (pizza pan, tall tube, mayonnaise jar, coffee cans, short fat cylinder, etc., labeled A, B, C,....)

* *

NOTES: If you are unable to obtain the materials for each student to make a cubic decimetre model, display one (and skip Activity A).

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WITH A LITRE BIT...

TASK: To find the volumes, to the nearest litre, of containers of many shapes

ACTIVITY: In an earlier activity, a litre was defined to be the volume of a cube measuring a decimetre (10 centimetres) on each edge. While this cube is an easy shape to remember when trying to "picture" a container having a volume of one litre, there are many other shapes which have a volume of one or more litres.

A. Which of the labeled containers has a volume of about one litre? (Use the one-litre container, water and funnel to find out.)

B. Some of the labeled containers hold more than one litre.

1. Write down the letter-name of each of these larger containers and the volume (to the nearest litre) of each container.

2. Again, check your estimates using the material provided.

EXTENSION: Suppose you were in the business of selling some expensive liquid by the litre. You decide to package it in one-litre containers which will make the buyer feel he is getting a lot for his money. Find, sketch, make or describe the shapes of some one-litre containers that would do this.

MATERIALS: A one-litre container
Several other containers labeled A, B, C, etc. (from 0.5 litre to 8 litres)
Some water (or substitute for water)
Funnel

* *

NOTES: (a) The "earlier activity" mentioned in the introduction above is the volume activity A LITRE, IN ANY SHAPE, IS STILL...
(b) This activity differs from the "earlier" activity in that (1) no litre model is on display and (2) the objects involved have a larger range of volumes.
(c) Make certain that some of the objects used here have a volume of one litre.

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VOLUME BY WATER

TASK: To estimate the volume, in millilitres, of familiar containers

ACTIVITY:

1. On a sheet of paper, write the name (letter) of each container.
2. Next to each name, write an estimate of the volume, in millilitres, of the container.
3. Check your estimates by using the water and the graduated cylinder.

MATERIALS:

Water
Graduated cylinder
Funnel
Several containers labeled A, B, C,...etc.

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VOLUME BY CUBES

TASK: To find the volume of containers (to the nearest millilitre) using one-millilitre cubes

ACTIVITY:

A. Each of the little cubes has a volume of one millilitre.

1. Use the cubes to find the volume, in millilitres, of each labeled container.
2. When you have measured the volume of all of the containers, check your measures against your teacher's list of exact measures. If your measures are not the same as those on your teacher's list, go to Part B to find out why.

B. 1. Did you have a measure which was larger than the correct measure given on your teacher's list? If so, measure the volume of any such object again.

2. The measures on your teacher's list were obtained by using water and a measuring cylinder. If you did this exercise correctly, your measures should have been smaller than those of your teacher. Why?

3. a. Which of the following materials would be better to use in finding volume measures?

little cubes
water and a measuring cylinder

b. Why?

EXTENSION: Suppose that you had only the little one-millilitre cubes to use in measuring the volumes of objects.

1. Find, draw, or describe shapes for which the one-millilitre cubes would give good estimates of volume.
2. Find, draw, or describe shapes whose volume would be very difficult to measure carefully using the one-millilitre cubes.

MATERIALS: Containers labeled A, B, C, D, etc.
Some millilitre cubes (250-500 will be needed)
List of exact measures

* *

NOTE: Activity B.3 and the Extension get at the question of appropriate measuring materials. They assume that the student has done the activity VOLUME BY WATER.

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CUBIT

TASK: To estimate the volume, in cubic metres, of large objects

ACTIVITY:

A. Using the 12 sticks and 8 "corners" provided, make the frame of a large cube.

B. The frame that you built in Part A measures one metre along each edge. It has a volume of one cubic metre. Place the cubic metre frame in the corner of this room. Estimate the number of such frames that it would take to fill this room. That is, answer the question: "What is the volume of this room in cubic metres?"

C. Use the trundle wheel to check your answer.

D. Do the activity LITRE ME before disassembling the cube.

MATERIALS: Cubic metre frame
Trundle wheel

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LITRE ME

TASK: To find the volume, in litres, of a person*

ACTIVITY:

A. 1. Have a member of the group sit inside the cube.

2. Think about being able to squash the person into a lump. About how many of that person would fit into the cube?

3. The cube has a volume of 1000 litres. Based upon the estimate you just made, what is the volume, in litres, of that person?

4. Check your estimate in the manner indicated by your teacher.

B. Repeat Part A for each member of your group. Check your estimate for each person before moving on to the next.

C. Take apart the cubic metre frame.

*An exercise for 4 - 5 persons.

EXTENSION: In other activities, you learned two important things: First, a man is — roughly speaking — made of water. The human body is much like "jellied water"; a lump of flesh has about the same mass as a "lump of water" of the same size. Second, a lump of water that has a mass of one kilogram will also have a volume of one litre. Use these two facts to check your estimates, Parts A and B, of the volume in litres of other persons in your group.

MATERIALS: 3 or 4 other persons
Bathroom scale
Cubic metre frame

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WHAZZIT HOLD?

TASK: To estimate and check the volume, in millilitres, of some common containers

ACTIVITY: The cube at this station measures one decimetre along each edge; it has a volume of one cubic decimetre (one litre). Use it as a model in making the estimates asked for in this activity.

A. Make a list of the containers at this station.

B. 1. Circle the names of those containers that you think will hold about 1000 millilitres (one litre) of water.

2. Estimate, in millilitres, the volume of water that each of the other containers will hold.

C. When you have completed all estimates, check your estimates by using the graduated cylinder and some water.

MATERIALS: A decimetre cube (like the one used in the volume activity A LITRE, IN ANY OTHER SHAPE, IS STILL...)
Several small containers which will hold from 0.25 litre to one litre of water (e.g., coffee cup, various sizes of pop bottles, milk carton, food jars, small pot, pie plate, etc.)
Water
Graduated cylinder
Funnel
Paper towels

* *

NOTES: (a) As in the activity A LITRE, IN ANY OTHER SHAPE, IS STILL..., the students are provided with a model decimetre cube to aid in making estimates.
(b) This activity differs from A LITRE, IN ANY OTHER SHAPE, IS STILL... in that the volumes involved are smaller. Here the largest is about one litre.

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MEASURE UP

TASK: To make your own 250-millilitre cylinder

ACTIVITY:

A. Use the ruler and pen to draw a line straight down the side of the glass. Let it dry for a minute or two.

B. With the help of the funnel, pour 25 millilitres of colored water into the 50-millilitre measuring cyclinder.

C. Now pour this 25 millilitres of water into the glass. Use the pen to mark the height of the water on the side of the glass.

D. Write "25" (for 25 millilitres) next to the mark you made on the glass.

E. Add another 25 millilitres of water to the glass. Mark the new water height and label it "50" (for 50 millilitres).

F. Add another 25 millilitres of water to the glass. Mark the water height and label it "75" (for 75 millilitres).

G. Continue the procedure until you have a 250-millilitre measuring container.

Hang on to this cylinder. You'll need it for other activities.

MATERIALS:
50-millilitre measuring cylinder graduated in one- or five-millitre intervals
Small funnel
Colored water
Felt-tipped marking pen (permanent ink)
Ruler
Clear plastic party glass large enough to hold 250 millilitres of water

* *

NOTES:
(a) It would be nice to have two such homemade cylinders per person.
(b) As soon as you complete this activity, use the cylinders to do the volume activity GUZZLE UP.

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GUZZLE UP

TASK: To measure the volume of liquids that you drink in one day

ACTIVITY: Using your personal 250-millilitre measuring cylinder, measure all the liquids that you drink on any one day. Here are some suggestions on how to do this.

A. Drink cold liquids (such as water, milk, fruit juice or soda) using your measuring cylinder. Keep a careful record of what you drink and how much (in millilitres) you drink each time.

B. For hot liquids (such as coffee, tea, cocoa or soup), use your measuring cylinder to measure the same volume of water by pouring water in your emptied coffee cup (soup bowl or whatever) and then measure that water using your measuring cylinder.

C. 1. What volume of cold liquids did you drink on the day you chose?

2. What volume of hot liquids did you drink?

3. What total volume of liquids did you drink?

D. Do you think that the figures you got in Part C would be the same on any day? Why?

E. What is the greatest volume of liquids consumed in one day by a class member? What is the least? What is the average volume consumed?

MATERIALS: At least one 250-millilitre cylinder per person (see NOTES)

* *

NOTES: (a) Use the 250-millilitre cylinder made in the volume activity MEASURE UP.
(b) Discuss the results as a class. Have the class prepare graphs, compute means, etc.
(c) Collect the results and store them. Repeat the activity at points throughout the years so that you have liquid consumption levels for the warmest and coolest times of the year. For each of those two times of year, you might get data from one school day and from one Saturday. Have your class analyze the total data obtained.

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SUBMERGE!

TASK: To find the volume of objects submerged in water

ACTIVITY:
1. Estimate the volume of each of the objects (in millilitres). Write these on a sheet of paper.
2. Now find the volume of each object by using the graduated cylinder, the water, and other materials provided and the fact that an object submerged in water will displace a volume of water equal to its own volume.

MATERIALS:
Large graduated cylinder
Water
Golf ball, with string attached
Weighted film canister, with string attached

****

NOTE: Students should have done the mass activity WATER WITCHERY before doing this one.

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NOBODY CAN MEASURE JUST ONE!

TASK: To find the volume of objects that have a very small volume

ACTIVITY: Sometimes we are asked to find the volume of a very small object. There are several ways this can be done.

1. Estimate the volume of just one of the items listed. Record it on the paper provided.

2. Using any method you choose, find the actual volume of just one of the items. Record it on the paper provided.

MATERIALS: Graduated cylinder
Water bucket
Funnel
Paper
Several small objects (beads, thumbtacks, paper clips, pennies, etc.)

* *

NOTE: This activity should be done after the mass activity WATER WITCHERY.

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MADISON AVENUE

TASK: To check the volume claims of manufacturers

ACTIVITY: Once upon a time, cereal manufacturers all sold a "family-sized" package of their cereal. Moreover, most of these manufacturers used the same size and shape box for their "family-sized" portion. Then, for some reason, many started to change the shape of the box used.

A. You have been given a cereal box. Suppose that all manufacturers used this same box for their "family-sized" package.
   1. Now suppose that the manufacturer of Bloatie Oaties introduces a new "super economy sized" package which is the same width but is one centimetre thicker than the old box. The new box is also two centimetres shorter. Use the cubes to determine which package would hold more Bloatie Oaties, the old or the new.
   2. How many millilitres more (or less) would the new package hold?

B. 1. Suppose the manufacturer of Crunchy Creatures also changed its box from the size you have been given to one that is the same width but one centimetre thinner and three centimetres taller. Use the cubes to determine which package (old or new) would hold more Crunchy Creatures.
   2. How many millilitres more (or less) would the new package hold?
   3. Which size package do you think would sell better — the old or the new? Why?

EXTENSION: Gram Flakes also used to make the same family-sized package as Bloatie Oaties and Crunchy Creatures. Suppose that the manufacturers of Gram Flakes made a new package which is two centimetres thinner and kept the same width. How much taller would it have to make its new package so that the new package (although it would look different) would hold about the same volume of Gram Flakes as the old package?

MATERIALS: Two cereal boxes of the same size, one labeled 'Bloatie Oaties' and the other labeled 'Crunchy Creatures'. (The individual serving sizes work well.) Enough centimetre cubes to fill three such boxes.

* *

NOTE: Use no formulas here! The intent is to use the cubes to build models which will (1) show the new box shapes and (2) answer the questions.

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GO SOAK YOUR HEAD!

TASK: To find the volumes of solids which have complex shapes

ACTIVITY:

A. 1. Estimate the volume of a thumb, a finger, and a hand (to the wrist) in millilitres.

2. Use the graduated beaker to check your guess.

B. The technique used in Part A.2. won't work for large objects that won't fit into the beaker. But you can handle the problem of "largeness" with the help of the other materials available (large bucket, container to catch overflow).

1. Find someone who thinks he can hold his breath for several seconds (under water).

2. Estimate the volume of his head (in millilitres).

3. Fill the large bucket to the brim with water (it should be so full that it is about to run over) and place it in the container to be used to collect overflow.

4. The "volunteer" should slowly stick his entire head under water and hold it there as long as possible!

5. Measure the overflow to find the volume of the head.

C. Repeat Part B for other large, weirdly shaped objects.

MATERIALS:

Part A	Part B
Graduated beaker	Large bucket
Water	Pan or sink to collect overflow
	Plastic basting syringe
	Towel

* *

NOTE: (a) This builds upon the displacement notion developed in the mass activity WATER WITCHERY.

(b) In Part B, the basting syringe is useful in getting the water out of the overflow collector and into the graduated beaker.

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OLYMPIC TRAINING

TASK: To become acquainted with the kilolitre and tonne

ACTIVITY:

A. A cubic decimetre (litre) of tap water has a mass of about a kilogram.
   1. How many cubic decimetres are there in one cubic metre?
   2. What is the mass of a cubic metre of water?
   3. What is the mass, in kilograms, of a kilolitre (1000 litres) of water?

B. A kilolitre of water has a mass of a tonne. The tonne is a unit of mass which is used to describe the mass of large items such as a train engine. The following test of strength will give you a feeling for a tonne.
   1. The containers you've been given will hold one or more litres of water.
      a. Choose a container and pour a litre of water into it. Using the balance, find the mass of that container of water.
      b. Does the container of water have a mass which is less than a kilogram, equal to a kilogram, or more than a kilogram? Why?

C. 1. Use containers of water to make masses of 1, 2, 3, 4, or 5 kilograms.
   2. Place 15 kilograms of mass in the big box. Do you think you can lift it? Try.
   3. Add another 5 kilograms of water masses. Do you think you can still lift the box? Try.
   4. Add another 5 or 10 kilograms of water masses. Do you think you can still lift the box? Do you think you could hold it for 5 minutes?
   5. Do you think you could lift a box containing 50 litres of water? How about a box containing 100 litres of water? (Few persons can lift a box containing 200 litres of water.

D. Look at the cube which measures one metre on each edge. If such a cube were a box made of very strong material, it would hold 1000 litres of water and would have a mass of 1000 kilograms (one tonne). About how many persons would it take to lift it?

MATERIALS:
Cubic metre frame
Cubic decimetre
Strong cardboard carton
Several coffee cans or plastic containers
Water

* *

NOTES:
(a) While this exercise seems to deal with mass (the tonne), its purpose is to emphasize the relationship between the kilolitre and the tonne. Hence, it is classified as a volume activity rather than a mass activity.
(b) Students should work in groups of 2 or 3.

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BATH TIME ECOLOGY

TASK: To decide which requires more water, a shower or a tub bath

ACTIVITY: It has been pointed out that people in the United States waste a large volume of water. Among other things, we have been asked to be careful about the volume of water we use when bathing. In this activity, you will find out how much water you use and answer the question, "Which requires more water, a tub bath or a shower?"

A. 1. Draw a sketch of a bathtub in your house. Give the length, width, and depth of the tub in centimetres.
   2. Identify, if possible, one or two persons who have tubs which have a shape different from yours.

B. In using a tub to take a bath, most persons fill the tub to a depth of 20 centimetres before entering the tub.
   1. Find how many litres of water would be required to fill your tub to a depth of 20 centimetres. (Many methods are possible.)
   2. Describe how you found the volume (for a tub bath).

C. Now design a way of finding out how many litres of water you use in taking a shower. In reporting this volume, describe how it was found.

D. Discuss the question, "Which requires more water, a tub bath or a shower?"

MATERIALS: This depends upon the method used by the students. They may need such things as rulers, pails, clocks, graduated cylinders, etc.

* *

NOTES: (a) In addition to providing an awareness of large volumes, this is an integrating activity which provides experience in designing, executing, and reporting an experiment and in interpreting the results of that experiment.

(b) Students can graduate a pail by using a plastic pail, an indelible marking pen and a one-litre measure.

(c) The data gathered by individual class members can be meaningfully treated with simple statistics as part of the discussion. That is, the data can be graphed; the mean, range, etc. can be computed.

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WATER, WATER ALL AROUND

TASK: To estimate the number of litres of water used by an "average" person in a single day

ACTIVITY: In order to ensure that we have enough water, city planners must have some estimate of the volume (in litres) of the water "consumed" by each person each day. By water "consumed" they mean water used in any way by a person (to drink, bathe, wash clothes, etc.). Suppose that you and your classmates have just been hired to obtain such an estimate.

A. Make a list of the ways in which you personally "consume" water each day. For instance, consider such daily uses of water as the following: drinking(plain, or in tea,etc.)
brushing teeth
bathing
flushing a toilet

You should be able to find many more ways that you use water.

B. 1. Decide how to get an estimate of the volume of water each person requires each day for each of the uses listed in Part A.
2. Obtain estimates of the daily volume of water each person requires for each of the uses listed in Part A. (Consider: have some uses that each person will estimate and some uses that will be estimated by some, but not all, persons in your group.)
3. For each use listed in Part A, decide how much water would be used daily by an "average" person in your class.
4. What is the total volume of water needed each day by an "average" person in your class?

C. Using the information obtained in Part B, prepare a report to be presented to the City Council. Consider the use of charts, graphs, and drawings in making that report.

D. Discuss the average figure obtained. How accurate is it? What conditions of sampling affect that average figure?

EXTENSION 1: Suggest some ways in which a person could reduce the water he consumes each day and estimate the volume of water the "average" person could save daily if he followed your suggestions.

EXTENSION 2: Estimate the daily water consumption of an "average" family. Consumption here would include lawn watering, car washing, dish and clothing washing, etc., as well as the personal uses you listed in Part A.

MATERIALS: Whatever is identified as being needed

* *

NOTES: (a) While this activity could be done by a single person, it is much better suited for a group or class project. It has great potential as an integrating activity in that it lends itself to statistical analysis and the discussion of sampling problems. It has implications for science and social studies; there is good reason to report the results in some way (school newspaper or local media).

(b) The volume activities BATH TIME ECOLOGY and GUZZLE UP should be done before this one as they provide major data for Part A.

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THE METRIC GOURMET

TASK: To write a favorite recipe using grams (kilograms), millilitres (litres), and degrees Celsius

ACTIVITY: Many persons still measure things in terms of an old measuring system called the English System (or Customary System) when cooking. Such persons use ounces and pounds rather than grams and kilograms. They use teaspoons, tablespoons, cups, pints, and quarts instead of millilitres and litres. They set their ovens and electric frying pans to temperatures measured in degrees Fahrenheit rather than degrees Celsius. A main reason that people continue to use these old measures is that they do not know how to "convert" their recipes to metric units of measure. In this activity, your task is to help them to change over by taking a recipe which gives measures in the old units and rewrite it in terms of grams (kilograms), millilitres (litres), and degrees Celsius.

A. Get a copy of a favorite recipe which uses old measures. (Somebody you know probably still uses such recipes.) On a sheet of paper, copy the recipe's list of ingredients and the preparation directions, but temporarily omit any measure. Just leave space for the measures.

B. Gather all of the ingredients necessary to use the recipe.

C. Put the metric cooking thermometer in the oven and set the oven to the temperature, in degrees Fahrenheit, required by the old recipe. Leave the thermometer there for at least 15 minutes. While waiting, go on to Part D.

D. Measure each ingredient twice. First measure it with the old units; then measure it using your balance and metric masses or your 250-millilitre measure. Also recall that a tablespoon is a 15-millilitre measure and a teaspoon is a 5-millilitre measure. As you obtain the metric measure of an ingredient, write that measure--in grams (kilograms, millilitres, litres) -- next to the ingredient on your copy of the recipe.

E. Using an oven mitt, remove the metric cookery thermometer from the oven after the oven has had at least 15 minutes to heat. Read the thermometer and record the temperature, in degrees Celsius, in your recipe.

F. As long as you have gone this far, why not make whatever the recipe describes?

MATERIALS: Metric kitchen scale or balance and metric masses
Metric cooking thermometer (goes up to at least 240 degrees Celsius)
A 250-millilitre cylinder (see volume activity MEASURE UP)

* *

NOTE: This activity brings together several measurement ideas. With some coordination of efforts, it could result in a metric cookbook. The cover (and any illustrations) provide opportunities for art work; any forward, comments on measure or such call upon language skills. It is a nice unifying activity.

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GOLD!

TASK: To divide a volume of gold dust equally between two miners

ACTIVITY: Container A holds 800 millilitres of gold dust just panned by two partners. Unfortunately they have no container that holds 400 millilitres and neither will permit the division to be done by approximation ("eyeballing").

After some searching, they find two other containers, A and B. Container B holds 500 millilitres and Container C holds 300 millilitres.

1. Using only the materials given, find a way to divide the gold dust into two equal portions of 400 millilitres each. Keep a record of how you do it so that you can explain your method to others.

2. When transferring the gold dust from container to container, use the scraper to scrape excess dust from a container after it has been filled. Work over the sheet of paper so that no dust will be lost.

MATERIALS: Three containers labeled A, B, and C (see separate page of NOTES)
Some "gold dust"
Scraper (e.g., ruler, spatula, tongue depressor, or knife)
Large sheet of paper

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TEACHER'S NOTES ON "GOLD!"

The activity "GOLD" is one to which students might return again until they solve it, so do not reveal a solution. In addition to providing experience in volume measure (seeing given volumes in different— shaped containers) and use of measuring instruments, it requires some good mathematical analysis. Make a contest of it if you wish. The following notes are directed at setting up the activity, an activity which is easy to store so that it is always available.

(a) Students can work alone or in pairs.

(b) You will have to construct the three containers to fit the volume specifications given. In doing so, there are three important rules you should follow in order that the result will be a challenging (but workable) activity.
1. No two containers should have the same shape. Cut them from paper cones, plastic bottles (inverted with the cap on), a hollow ball, etc. But the container so that it just holds the desired volume of dust (sand, whatever).
2. The 800-millilitre container (Container A) should be cut from a sphere or cone so that it is unreasonable to try to "eyeball" half the volume.
3. The containers must be constructed with care. (Gold dust is valuable!) The sum of the volumes of Container B (500 millilitres) and Container C (300 millilitres) should be the volume of Container A (800 millilitres).

(c) One solution requires 9 moves. The chart below shows the volume, in millilitres, of gold dust that is in each container at the end of each move.

Move	Location (by container name and volume) of Gold Dust		
	A	B	C
0	800	0	0
1	500	0	300
2	500	300	0
3	200	300	300
4	200	500	100
5	700	0	100
6	700	100	0
7	400	100	300
8	400	400	0

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HANDY AREA

TASK: To estimate the area in square centimetres of your hands

ACTIVITY:

A. Draw an outline of your left hand on the square-centimetre grid paper. Approximate the area of your hand by counting the squares.

B. Does your right hand have the same area (in square centimetres) as your left hand? If not, which has the greater area? How much greater is it?

C. Use the square centimetre paper to compare the areas of your feet (with shoes off).

MATERIALS: Square centimetre graph paper

* *

NOTE: The technique is simple here--just count the squares as best you can. The tediousness of this method will provide motivation for better techniques.

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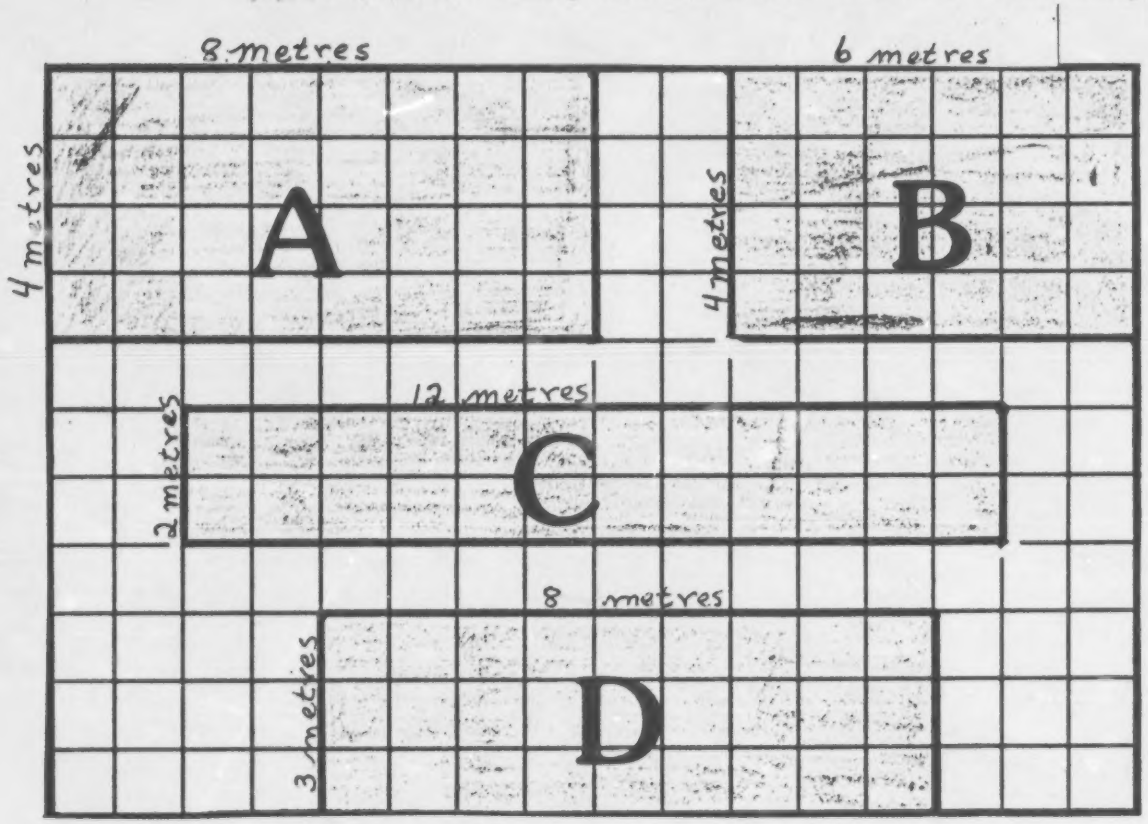
STRAWBERRY PATCHES

TASK: To enclose a maximum area with a given amount of fencing

ACTIVITY: A. A certain gentleman farmer (let's call him Duane) had 24 metres of fencing to make a rectangular enclosure within which to grow strawberries. He wanted to enclose the largest possible area with the fencing available. To help decide how to best use the fencing, Duane drew some sketches of possible fields on a sheet of square-centimetre paper. Among his sketches were the following four:



1. Duane made mistakes with two of the sketches. Which ones? What's wrong?

2. Two of Duane's sketches show fields which could be enclosed with exactly 24 metres of fencing. Are the areas (in square metres) of these two fields the same? If not, which is larger?

3. Draw sketches of several other fields which could be enclosed with exactly 24 metres of fencing and find the area of each field.

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4. Describe the rectangular field--enclosed with exactly 24 metres of fencing--which has the largest area and tell what that area is.

B. Describe the rectangular field of largest area which could be enclosed with exactly 20 metres of fencing.

Optional Activities: Again suppose that Duane has 24 metres of fencing to enclose the largest possible strawberry patch. What would be the dimensions of that patch if:

(a) one side of the patch didn't require fencing because he could use the side of a barn for it?

(b) only two sides of the patch require fencing because he is going to build it in the corner of a walled field (old stone wall) so that stone walls will form two sides of the patch?

MATERIALS: Several sheets of square-centimetre paper

6

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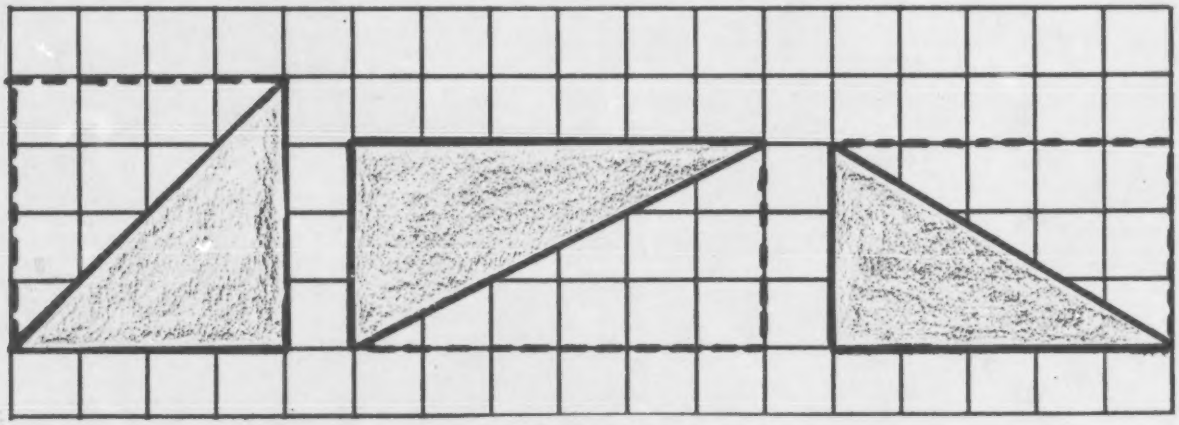
AREA OF A RIGHT TRIANGLE: HALF A RECTANGLE IS BETTER THAN NONE

TASK: To develop the concept that the area of a right triangle is one-half the area of an appropriate rectangle.

ACTIVITY: A triangle with a "square corner" is called a right triangle. It is easy to find the area of a right triangle by simply visualizing it as half of a rectangle. Since we can find the area of any such rectangle without trouble, the area of the right triangle can be obtained with only half a thought.

Each triangle shown below, for instance, has been dropped on a piece of square-centimetre paper and thus enclosed within a rectangle. The areas, in square centimetres, of the three triangles pictured are 8, 9, and 7 1/2.



Find the area, in square centimetres, of each right triangle on the sheet provided.

MATERIALS: drawings of several right triangles
sheets of square-centimetre paper
scissors

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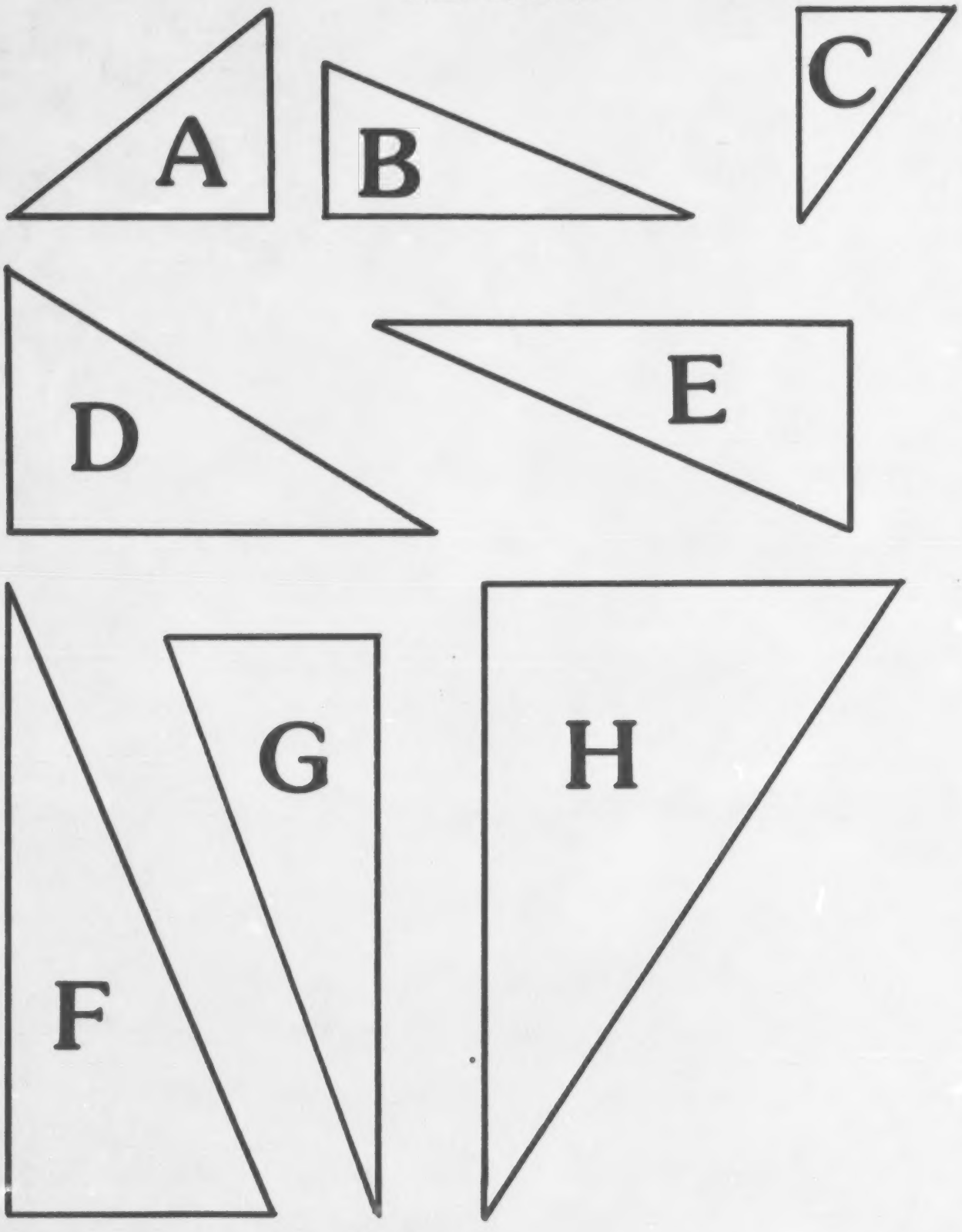
RIGHT TRIANGLES



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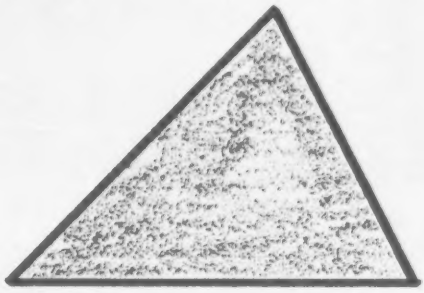
TRIANGLES THAT JUST AREN'T QUITE RIGHT

TASK: To develop the concept that the area of a triangle is one-half the area of an appropriate rectangle.

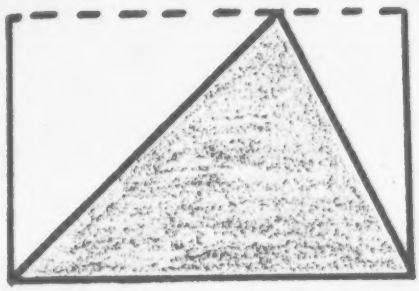
ACTIVITY: A triangle which has a square corner is called a right triangle. There are, of course, lots of triangles which don't have a square corner. This doesn't make them wrong triangles--it's just that they're not quite right. Let's call such triangles <u>non-right triangles</u>.

One nice thing about a right triangle is that you can easily find its area by thinking about that right triangle as being half a rectangle. While non-right triangles aren't quite so nice, you can use what you know about right triangles to help you find the area of a non-right triangle. Part A below will give some hints on how to do this.

A. Suppose you needed to find the area, in square centimetres of the triangle pictured here. Since the triangle has no square corner, we can't picture it as half a rectangle. What to do?



1. With a bit of fiddling, you can drop the triangle on a piece of square-centimetre paper in such a way that it is enclosed within a rectangle as shown in the sketch. That rectangle can be viewed as consisting of three triangles--two right triangles and the non-right triangle we started with. Find the area, in square centimetres, of each of the two right triangles.



2. Find the area, in square centimetres, of the rectangle which encloses the three triangles.

3. Use the information from Exercise 1 and 2 to find the area of the non-right triangle.

B. Use the procedure illustrated in Part 2 to find the area, in square centimetres, of each of the non-right triangles on the sheet provided.

MATERIALS: drawings of several non-right triangles
sheets of square-centimetre paper
scissors

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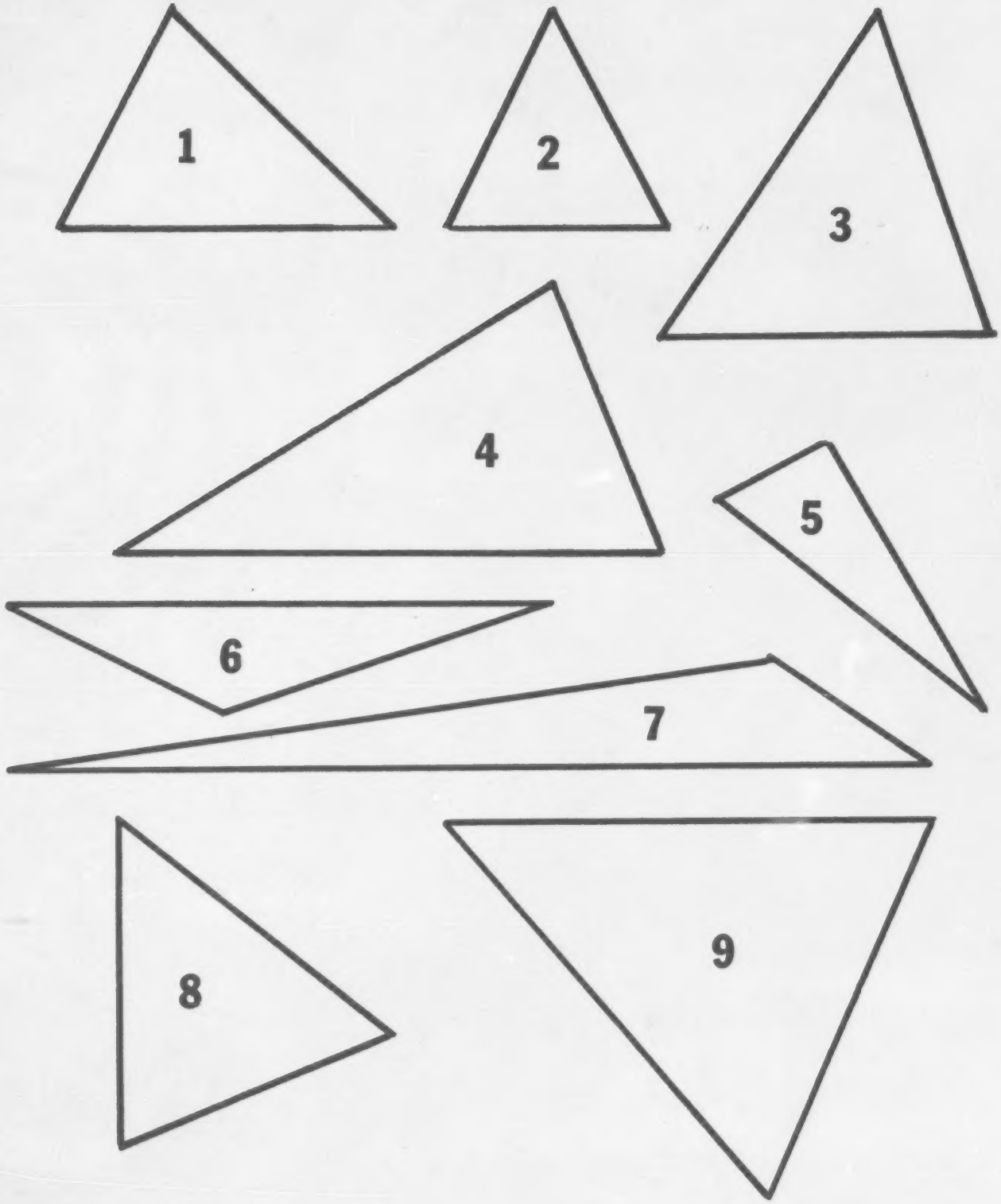
"NON-RIGHT TRIANGLES"



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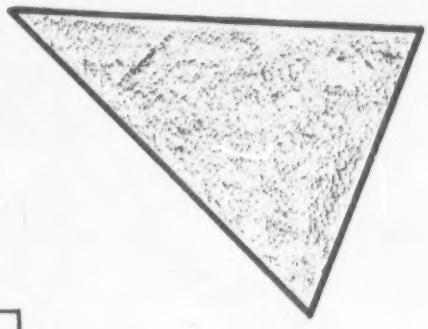
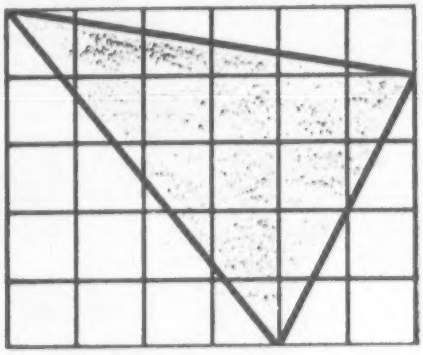
AREA OF TRICKY TRIANGLES

TASK: To develop the concept that the area of a triangle can be found by enclosing the triangle in a rectangle

ACTIVITY: The triangles of this activity are not just non-right, they're also tricky in the sense that it is a bit tricky to find a rectangle to enclose them (when trying to find their areas). The problem with these peculiar polygons is that no side of such a triangle will be a side of the rectangle needed to enclose it. Let's look at an example.

A. The triangle shown here is a tricky triangle. It's tricky because--after placing it on a piece of square-centimetre paper and juggling it about for a while--we find that the rectangle which encloses it looks like this:





Since no side of the triangle is also a side of the rectangle which encloses it, the triangle is one of the tricky type.

The enclosing rectangle can be viewed as being comprised of four triangles: three right triangles and the original tricky triangle. Find the area, in square centimetres, of each of the three right triangles.

1. Find the area, in square centimetres, of the rectangle which encloses the four triangles.

2. Use the information obtained in Exercises 1 and 2 to find the area of the tricky triangle.

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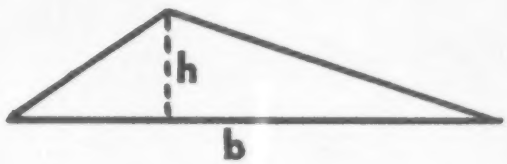
B. Use the procedure illustrated in Part A to find the area, in square centimetres, of each of the tricky triangles on the sheet provided.

OPTIONAL ACTIVITY: Use the diagram at the right and the enclose-it-in-a-rectangle area procedure of Activities 2 - 4 to establish that the formula for the A of a triangle is:

$A = \frac{bh}{2}$ where b and h are the lengths (in U's) of the segments indicated.



MATERIALS: Drawings of several tricky triangles
Square-centimetre paper
Scissors

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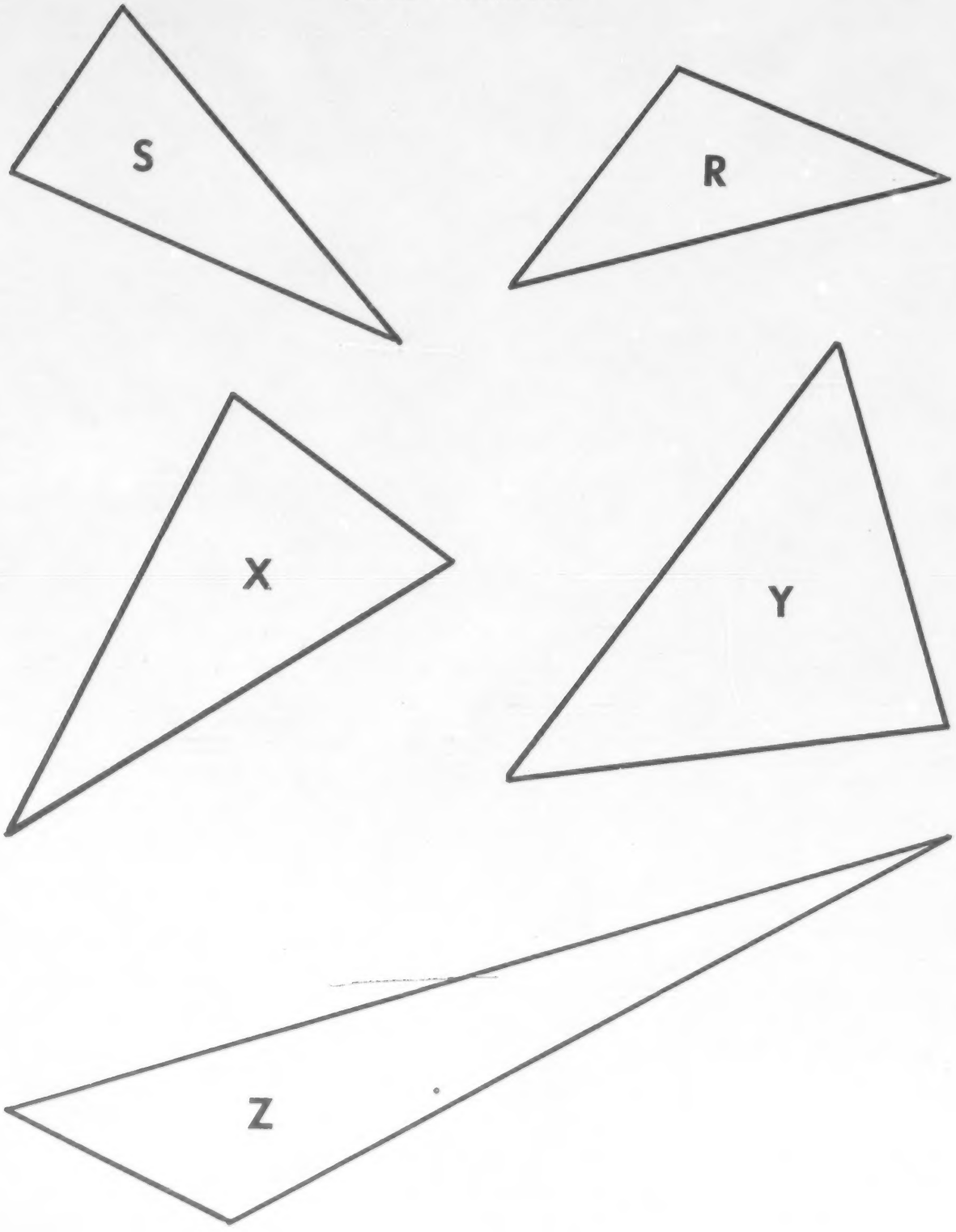
TRICKY TRIANGLES



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AREAS OF POLYGONS (NO FORMULAS NEEDED)

TASK: To determine the area of a polygon using techniques developed to find the area of a triangle.

ACTIVITY: Using the enclose-it-in-a-rectangle technique developed to find the area of a triangle, find the area (in square centimetres) of each polygon on the sheet provided.

MATERIALS: Drawings of several polygons
Sheets of square-centimetre paper
Scissors

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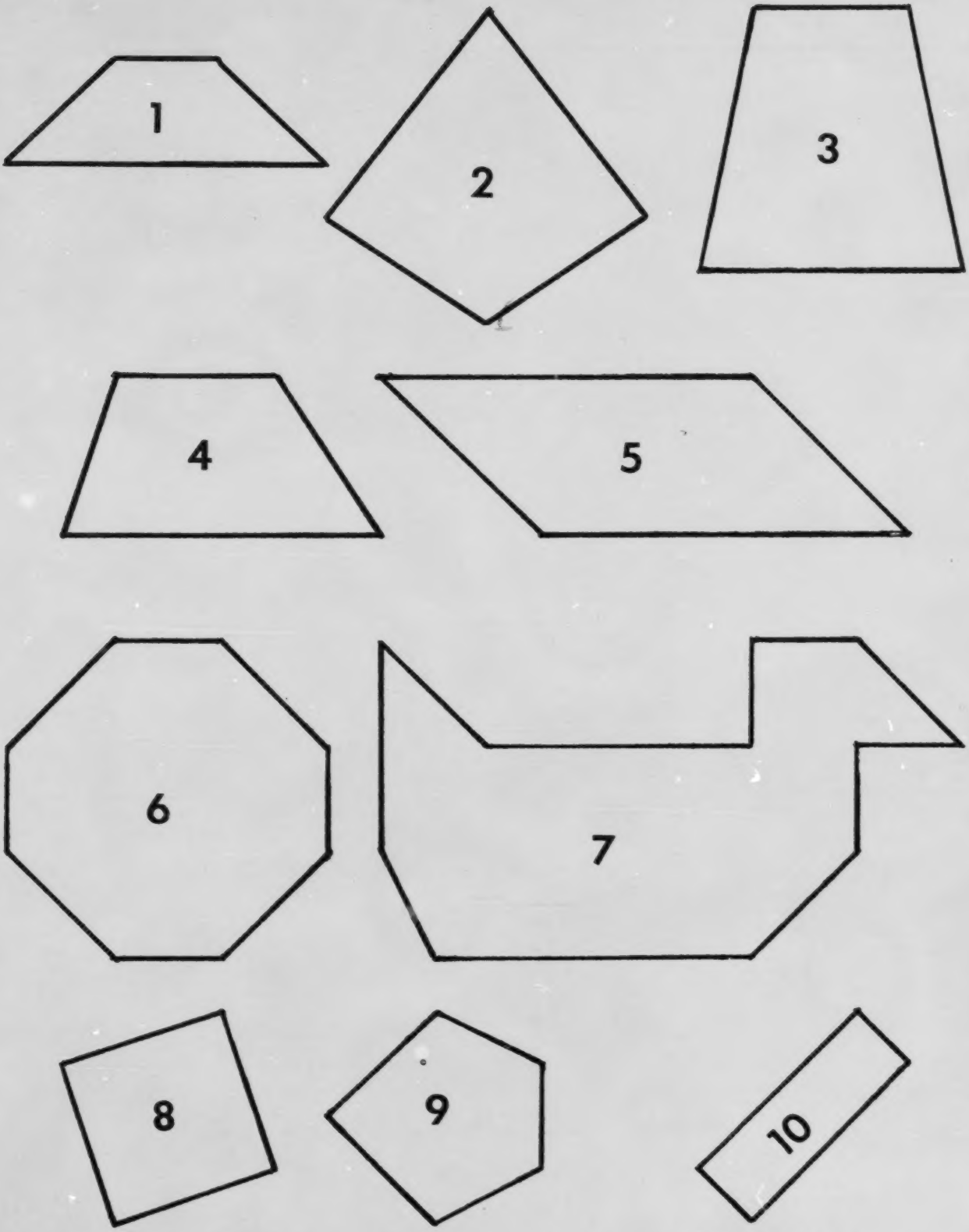
POLYGONS



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SQUARE DEALINGS ON A GEOBOARD

TASK: To determine squares of different dimensions

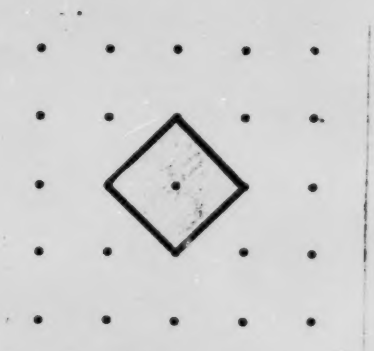
ACTIVITY: The square pictured at right is very special. For one thing, it is the smallest square having a nail at each corner which can be constructed on the geoboard.

A square such as the one shown has sides which are 1 unit (1u) long; it's called a unit square. The region enclosed by a unit square is said to have an area of one square unit (which we'll denote by writing 1 [u]).

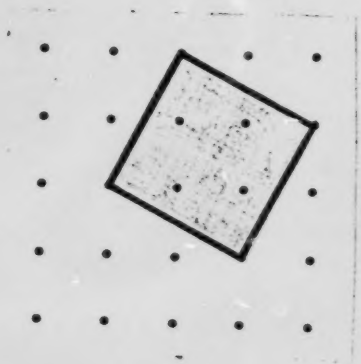
1. The square pictured at the right has an area of 4 [u]. What is the area (in [u]'s) of each of the squares shown below? (You may have to use the enclose-it-in-a-rectangle technique to find out.)

(a)

(b)



(c)



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2. The geoboard can be used to display many squares having a given area. There are, for instance, nine different locations for a square having an area of 4 [u] . There are also many squares having an area of 1 [u] and some having an area of 9 square units. In fact, it is possible to display squares of <u>eight different areas</u>. (Those 8 areas having the following measures (in [u] 's): 1, 2, 4, 5, 8, 9, 10 and 16.) Find an example of a square for each of these areas and sketch each such example on a Geoframe Practice Sheet.

   (You can use a corner torn from this page to check whether or not the figure you've constructed has square corners.)

OPTIONAL ACTIVITY: If u (shown in the first diagram of the activity above) is the unit length, the smallest <u>triangle</u> that can be shown on the geoboard has area $\frac{1}{2}$ u ; the largest has area 8 u . Find, if you can, a triangle with each of the following areas:

1 [u] $\frac{3}{2}$ [u] 2 [u] $\frac{5}{2}$ [u] 3 [u] $\frac{7}{2}$ [u]

4 [u] $\frac{9}{2}$ [u] 5 [u] $\frac{11}{2}$ [u] 6 [u] $\frac{13}{2}$ [u]

7 [u] $\frac{15}{2}$ [u]

Draw a sketch of each using Geoframe Practice Sheet.

MATERIALS: A geoboard and some rubber bands
Some Geoframe Practice Sheets

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GEOFRAME PRACTICE SHEET

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TRUNK AREA

TASK: To find the area of an elephant by taking its mass

ACTIVITY:

A. 1. Trace the outline of the figure on a sheet of the plain paper provided.

B. 1. Cut out the figure that you drew.

2. Using the balance and cut-up pieces of square-centimetre paper, find the area of the figure correct to the nearest square centimetre. (Place the cut-out figure on one pan of the balance. Cut rectangular pieces from the square-centimetre graph paper and place them in the other pan until the pans balance. The area of the cut-out figure is the same as the area of the rectangles in the other pan.)

MATERIALS: Silhouette of an elephant (see attached silhouette of PHLORA PACHYDERM)
Square-centimetre graph paper
Scissors
Balance

* *

NOTES:

(a) Paste PHLORA PACHYDERM to tagboard and cut out. This provides the tracing template for Part A.

(b) Be certain that the "plain paper" used in Part A is the same kind of paper used to make the square-centimetre graph paper. If it isn't, the conclusion in Exercise 3 of Part B will be false.

(c) Repeat this exercise for other irregular shapes. The technique (used again in such area activities as SQUARIN' OFF) is an important one. It merits practice.

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PHLORA PACHYDERM

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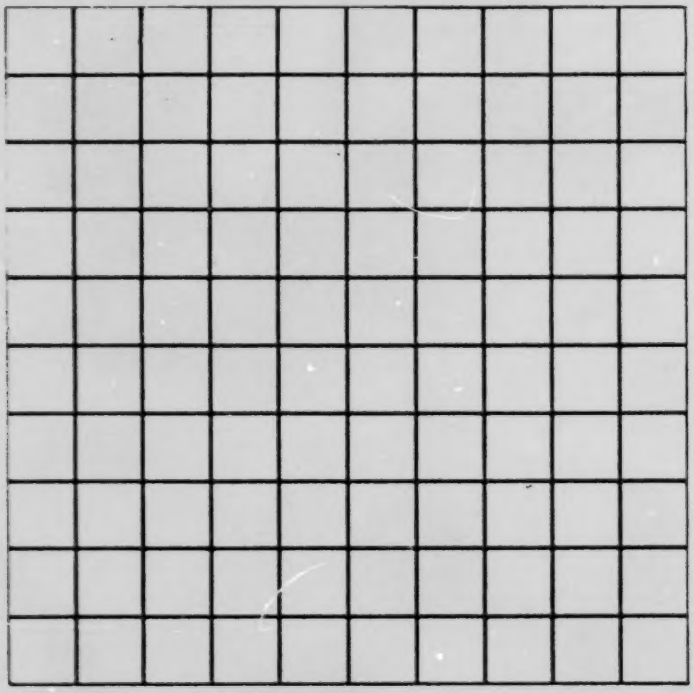
BIG SQUARES ... LITTLE SQUARES

TASK: To estimate areas in square decimetres and square centimetres

ACTIVITY: A. 1. Write down the name of each object displayed (or indicated) at this station.

2. The large square shown below has an area of one square decimetre.



Estimate the area, in square decimetres, of each of the objects you named above.

B. The little square below has an area of one square centimetre.

With the help of the estimates you made in Part A, estimate the area, in square centimetres, of each object you named.

MATERIALS: Provide (indicate) several surfaces to be measured. Include both relatively small objects (book cover, newspaper, student desk, etc.) and large objects (window, door, bulletin board, chalkboard, etc.)

* *

NOTE: Have individuals or groups present their estimates. Discuss them, the discussion being aimed at eliminating "far out" estimates and identifying those which are reasonable (of which there may be several). Announce the actual measures (which you can make at the time or ahead of time). Decide which of the estimates should be accepted as reasonable (and, again, there may be several).

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SPARE NOT THE ROD(S)

TASK: To use colored rods to find the areas, in square centimetres, of several shapes

ACTIVITY:

A. There are ten colors of rods used in this activity. Make a list of these colors. (See the ROD-AREA CHART.)

B. The rods can be used to find areas. Here's how.

1. The white rod is the smallest rod. Each of its faces has an area of one square centimetre. When such a rod is placed on a figure, then, it will cover an area of one square centimetre. Write '1 square centimetre' after the color-name for this rod on your list.

2. Pick up a rod of a different color. It has two small faces (at each end); each of these small faces has an area of one square centimetre. It also has four bigger faces. Use the ROD-AREA CHART to find the area of one of these bigger faces. That area is the area that this rod will cover when it is placed on a figure. Record that area, in square centimetres, next to the color-name for this rod on your list.

C. Select one of the drawings provided and use colored rods to cover it exactly. Then compute its area, in square centimetres, by using the information that you gathered in Part B. Repeat this activity for each of the drawings provided.

D. Your teacher will tell you how to check your answers.

MATERIALS: Colored rods
Copy of ROD-AREA CHART
Drawings of shapes that can be covered by rods (a sample WORKSHEET is attached)

* *

NOTES:

(a) Shapes like those on the attached sheet can be constructe by using square-centimetre paper. Trace the shapes onto plain paper using a sheet of typist carbon paper.

(b) The areas of the sample shapes are: face, 111 square cen timetres; FSU, 35 square centimetres; WYO, 70 square centimetres.

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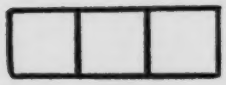
ROD AREA CHART

THERE ARE TEN COLORS OF RODS USED IN THIS ACTIVITY (RED, WHITE, BLUE, PURPLE, LIGHT GREEN, DARK GREEN, BROWN, YELLOW, ORANGE AND BLACK). USE THIS CHART TO FIND THE GREATEST AREA (IN SQUARE CENTIMETRES) THAT CAN BE COVERED WITH EACH COLOR OF ROD.

1 SQUARE CENTIMETRE

2 SQUARE CENTIMETRES



3 SQUARE CENTIMETRES

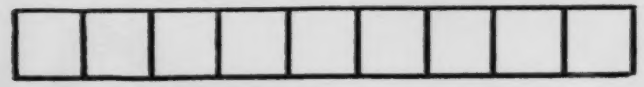
4 SQUARE CENTIMETRES

5 SQUARE CENTIMETRES

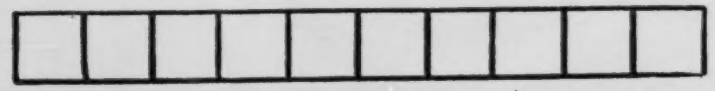
6 SQUARE CENTIMETRES

7 SQUARE CENTIMETRES

8 SQUARE CENTIMETRES



9 SQUARE CENTIMETRES



10 SQUARE CENTIMETRES

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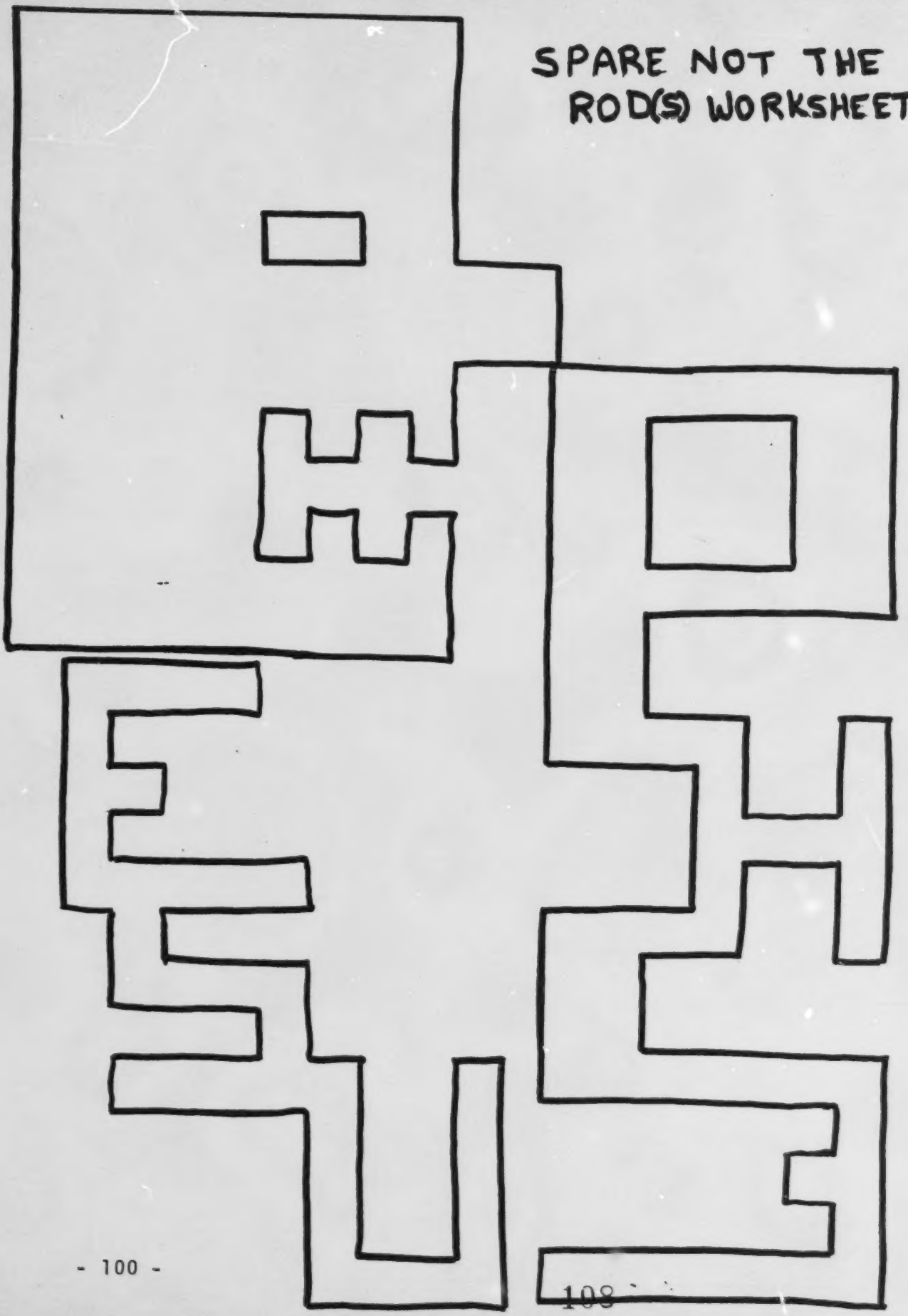
SPARE NOT THE ROD(S) WORKSHEET



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SQUARIN' OFF

TASK: To find the area and perimeter of your silhouette

ACTIVITY:

A. 1. Lie on the paper provided and have someone trace your silhouette. (Be sure to trace around each finger of your hands.)

2. Write down an estimate of

(a) the perimeter of your silhouette (in centimetres) and

(b) the area of your silhouette (in square decimetres).

B. 1. Using string and a metre stick, a decimetre trundle wheel or a measuring tape, check the perimeter estimate that you made in Part A.

2. Cut your silhouette out and dispose of any tape that's attached to it. Using the balance and the decimetre squares, check the area estimate that you made. (Note that the decimetre squares are cut from the same kind of paper that you used for your silhouette.)

MATERIALS:

Butcher paper
About 50 squares, one decimetre on a side, cut from the same butcher paper. Put these in a box labeled 'decimetre squares
Pens, crayons, etc.
String and metre sticks (for measuring tapes or decimetre trundle wheels)
Scissors
Masking tape
Balance

* *

NOTE: (a) Do the area activity TRUNK AREA before doing this one.

(b) This exercise could be done with <u>shadows</u> taken at different times of the day.

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SPREADING THE WEALTH

TASK: To learn how to find the area, in square centimetres, of small shapes

ACTIVITY:

A. 1. Use 12 pennies to make a rectangular array on the square-centimetre graph paper. Find the area, in square centimetres, of the rectangle which is covered (well, almost covered) by the pennies.

2. Make other rectangular arrays with the 12 pennies and find the area of each rectangle.

3. What is the approximate area (in square centimetres) covered by a single penny when it is part of an array?

4. Approximate the area of each figure on the COVERED WITH CASH WORKSHEET by covering each figure with an array of pennies.

B. Repeat the four exercises of Part A using quarters instead of pennies.

MATERIALS:
At least 35 pennies
At least 24 quarters
Sheets of square-centimetre graph paper
Copies of COVERED WITH CASH WORKSHEET

* *

NOTES:

(a) Although the area of a penny is close to 3 square centimetres, it "covers" a rectangle (square) with an area of 4 square centimetres when in an array of pennies. That is, each penny and the space between it and other pennies in the array is about 4 square centimetres. Thus, a shape which can be "covered" by an array of 10 pennies has an approximate area of 40 square centimetres.

(b) Since an array of 12 quarters covers an area of about 75 square centimetres, we can say that a single quarter in such an array covers about 6.25 square centimetres. Thus, a shape which can be covered by an array of 20 quarters has an approximate area of 125 square centimetres.

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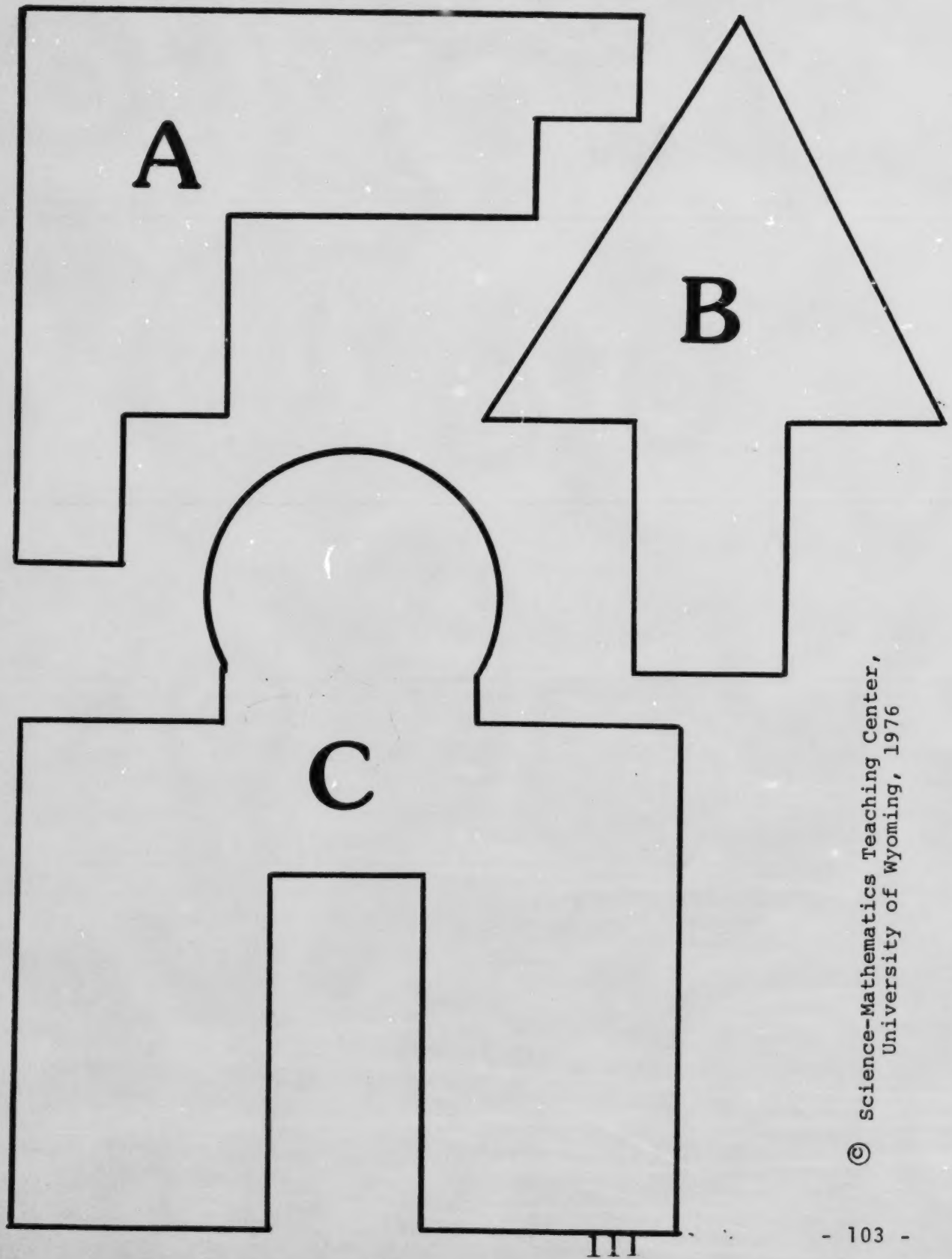
COVERED WITH CASH WORKSHEET



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THE STRIPPER

TASK: To find the area, in square metres, of large surfaces

ACTIVITY: Your teacher will indicate some large surfaces to be messured. With the help of 2 partners, use the "area strips" to find the area, in square metres, of each. USE NO FORMULAS.

MATERIALS: 2 "area strips" (see NOTES)
Tape of "flags" (see NOTES)

* *

NOTES: (a) The "area strips" are strips of paper, wallpaper, cloth, or whatever which are one metre wide and 10 metres long. They should be marked as follows:

ONE SQUARE METRE	ONE SQUARE METRE	ONE SQUARE METRE	ONE SQUARE METRE	ONE SQUARE METRE	ONE SQUARE METRE	ONE SQUARE METRE	ONE SQUARE METRE	ONE SQUARE METRE	ONE SQUARE METRE

(b) Use the gym or playground. Use tape or flags to indicate the corners of rectangular surfaces on walls, playing surfaces, or in fields. Make one dimension less than or equal to 10 metres so that the strips can be used.

(c) It would be nice to be able to mark a "model" surface in the play area and/or on a wall which is 10 metres by 10 metres. This would get students familiar with this large area unit used in giving the area of fields. The unit is a square dekametre.

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CEILING SQUARES

TASK: To estimate and check areas in square metres

ACTIVITY: A. Use the metre sticks to outline an area of one square metre. Use this "model" to estimate the area, in square metres, of

1. the ceiling of this room
2. each wall in this room

B. Use the trundle wheel to check each of the estimates that you made in Part A.

MATERIALS: Trundle wheel
Five metre sticks

* *

NOTES: (a) In doing this activity, you may wish to include the area of any windows and ignore irregularities in the walls and ceiling.

(b) Vary this activity by taking it outside. Mark the corners of large rectangular regions; have students first estimate and then check the area of each region. (Use walls of buildings as well as ground areas.)

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FLOOR PLANS

TASK: To find the areas, in square centimetres, of "mathematical shapes" (no formulas needed)

ACTIVITY: Use the given materials (not formulas) to find the area, in square centimetres, of each of the shapes on the MATHEMATICAL FLOOR PLANS WORKSHEET.

1. List the letters A-E and write down the area of each figure. You should be able to get an exact measure for each of these.

2. List the letters F and G. If you're clever, you can get exact measures for these two figures. Otherwise, you should be able to get good approximations.

MATERIALS: Cuisenaire rods
Plastic square-centimetre grid
Copies of MATHEMATICAL FLOOR PLANS WORKSHEET

* *

NOTES: (a) The technique used in the area activity AREAS OF POLYGONS (NO FORMULAS NEEDED) will work here to give "exact" measures. So will other techniques.

(b) You should do more problems like this with shapes designed by students or you.

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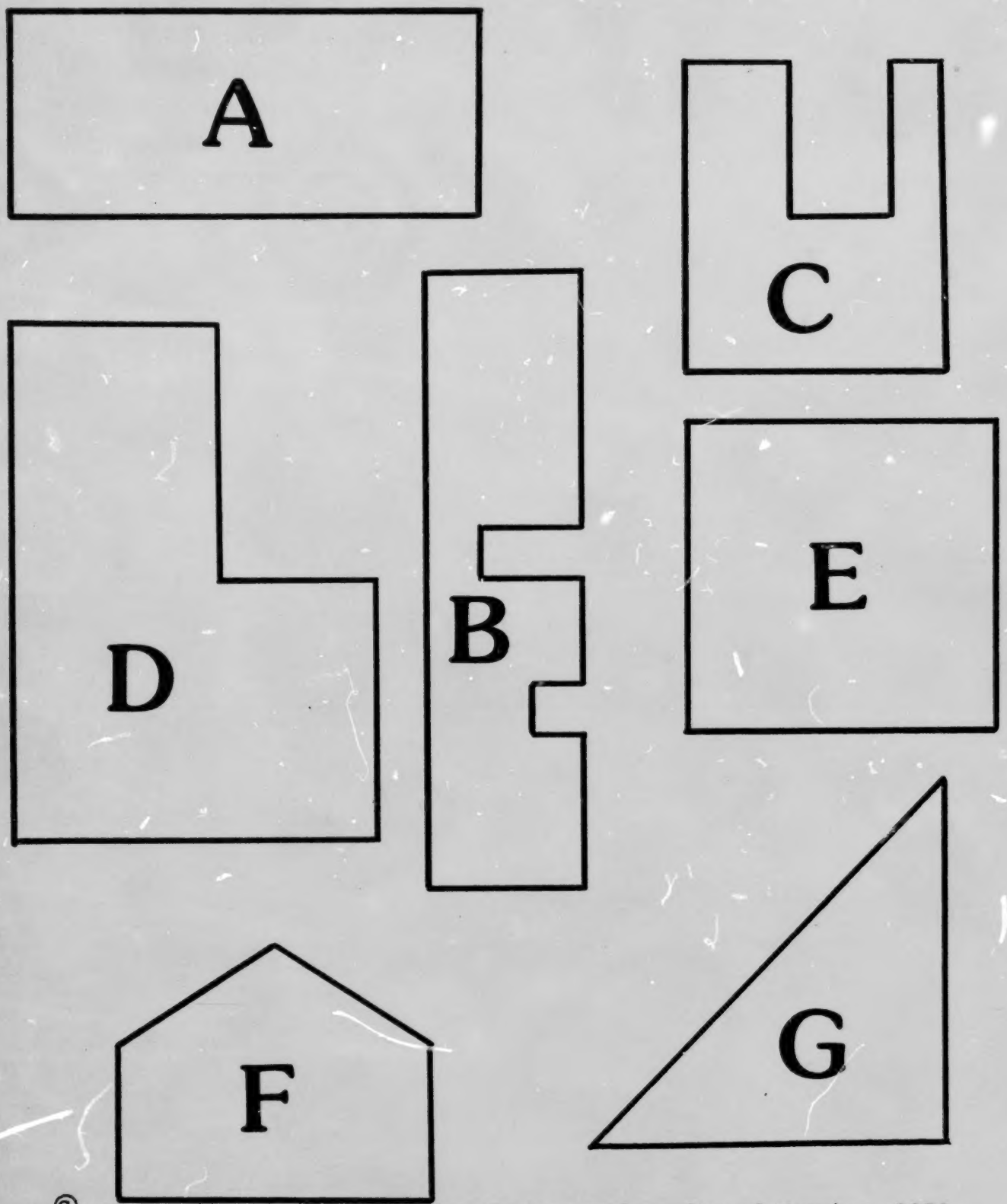
MATHEMATICAL FLOOR PLANS WORKSHEET



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NON-RECTANGULAR AREA

TASK: To estimate the area under a curve

ACTIVITY:
1. Make an estimate of the measure, in square centimetres, of the shaded area under the curve.
2. Use the white and orange rods to check your estimate.

MATERIALS: White and orange rods
Copies of NON-RECTANGULAR AREA WORKSHEET

* *

NOTE: White and orange Cuisenaire rods are appropriate. If these aren't available, cut white square centimetre pieces and orange pieces which are one centimetre wide and ten centimetres long.

The area under the curve is between 158 square centimetres and 176 square centimetres. You get 158 if you count only those blocks which fall under the curve entirely; you'll get 176 if you "cover" the curve entirely. Thus, a a good estimate of the area--a compromise of the two situations described above--is anything from 158 square centimetres through 176 square centimetres.

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NON-RECTANGULAR AREA WORKSHEET

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MAXIMIN

TASK: To obtain maximum and minimum surface area

ACTIVITY:

A. 1. Each face of the cubes used here has an area of one square centimetre. Take 12 cubes; using all 12 cubes, construct a rectangular solid with (1) maximum surface area and then (2) minimum surface area.

2. Repeat A.1 using 16 cubes.

B. Using whatever number of cubes you find necessary, construct the following:

1. A solid with a surface area of 13 square centimetres

2. A solid with a surface area of 20 square centimetres

3. A solid with a surface area of 23 square centimetres

MATERIALS: Some centimetre cubes (about 20)

* *

NOTE: You may have to emphasize that the "surface" of a solid is just the surface which is exposed when the cubes have been put together to form the solid.

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ON THE SURFACE

TASK: To find the surface area, in square centimetres, of common containers

ACTIVITY: A. Find the area, in square centimetres, of the entire outside of each container using only the materials given. NO FORMULAS NEEDED!

B. Check your answers with your instructor.

MATERIALS: Some small boxes and cans labeled A, B, C, etc. (e.g. recipe file box, can of tomatoes, can of mushrooms)
Sheets of square-centimetre graph paper
Lots of centimetre cubes
String
Scissors

* *

NOTES: (a) The idea is to have students get a reasonable measure of the area by tracing the outlines of each face and counting squares, by covering surfaces with cubes and counting, etc. Formulas are out of place here.

(b) Be certain to have the area measures ready (see Part B). If you calculate these areas using formulas, allow the students 10 percent variation on their approximations. Better yet, use the methods suggested in NOTE (a) to get your answers.

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SOLID AREA

TASK: To find the surface area of solids

ACTIVITY: Find the surface area of the geometric solids using the materials here. DO NOT use any formulas!

MATERIALS: Several geometric solids
String
Square centimetre paper
Felt tip pens
Scissors

* *

NOTE: This is like the area activity ON THE SURFACE but deals with standard geometric solids. See NOTES on the activity ON THE SURFACE.

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BALLOONS

TASK: To find the surface area of an inflated balloon

ACTIVITY:

1. Inflate a balloon until the end is well filled out.
2. Devise a method for finding a fairly good approximation of the surface area (in square centimetres) of the balloon (exclusive of the mouthpiece). Use any of the materials here. Be careful not to distort the area of the balloon (by pressing or squeezing it) as you work.
3. Draw a picture of your balloon and write an explanation of how you found its area. NO FORMULAS NEEDED!

MATERIALS: Balloons (tear-shaped are best, spherical are okay, cigar-shaped are not-so-hot, twisted shapes are lousy)

String

Scissors

Masking tape

Tracing paper

Colored pens

Square-centimetre graph paper

Balance

* *

NOTES:

(a) Students should do the area activity TRUNK AREA before doing this one.

(b) <u>One technique</u> is to divide the surface area into smaller areas using a pen. Trace these areas onto the tracing paper, transfer them to heavier paper (graph), and use the balance to find the area (as in the activity TRUNK AREA).

(c) In doing the "dividing" suggested in NOTE (b), a clever student might divide the surface into congruent pole-to-pole sections like those created by lines of longitude on a globe. It is then possible to find the area of just one such sector and to multiply by the number of sectors.

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AREA MATCH

TASK: To match circles and rectangles that have the same area.

ACTIVITY: A. Take one circle at a time from the envelope and match it with the rectangular shape on the worksheet AREAS AND SHAPES which you feel has the same area.

B. When you have finished making your estimates, your teacher will tell you how to check them.

EXTENSION: Using the technique of comparing masses on a balance, one could ask: "Given a circle, can you construct a rectangle with the same area (and vice versa)?" In doing so, the area formulas for circles and rectangles need not be used.

MATERIALS: Copies of the worksheet AREAS AND SHAPES
Packet of circles cut from the attached CIRCLE TEMPLATE and placed in an envelope
Balance (for EXTENSION only)

* *

NOTES: Cut out the circles on the CIRCLE TEMPLATE and place them in an envelope. For longer life--and to keep the shapes from curling-glue the TEMPLATE sheet to heavy paper before cutting.

The matching of these circles with the rectangles on AREAS AND SHAPES is as follows:

CIRCLE	RECTANGLE
1	H
2	C
3	J
4	E
5	B
6	I
7	D
8	A
9	F
10	G

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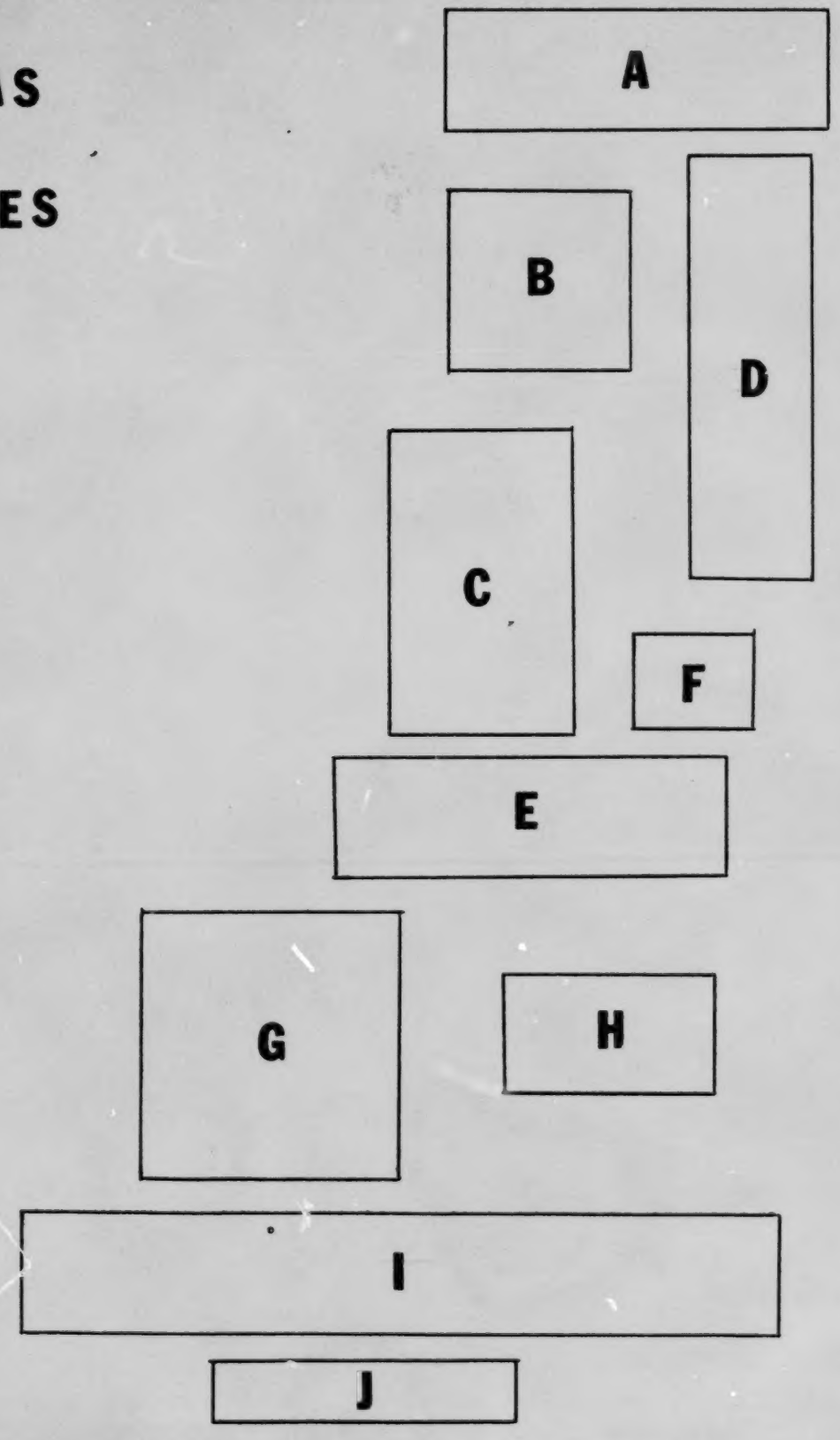
AREAS & SHAPES

A_____
B_____
C_____
D_____
E_____
F_____
G_____
H_____
I_____
J_____



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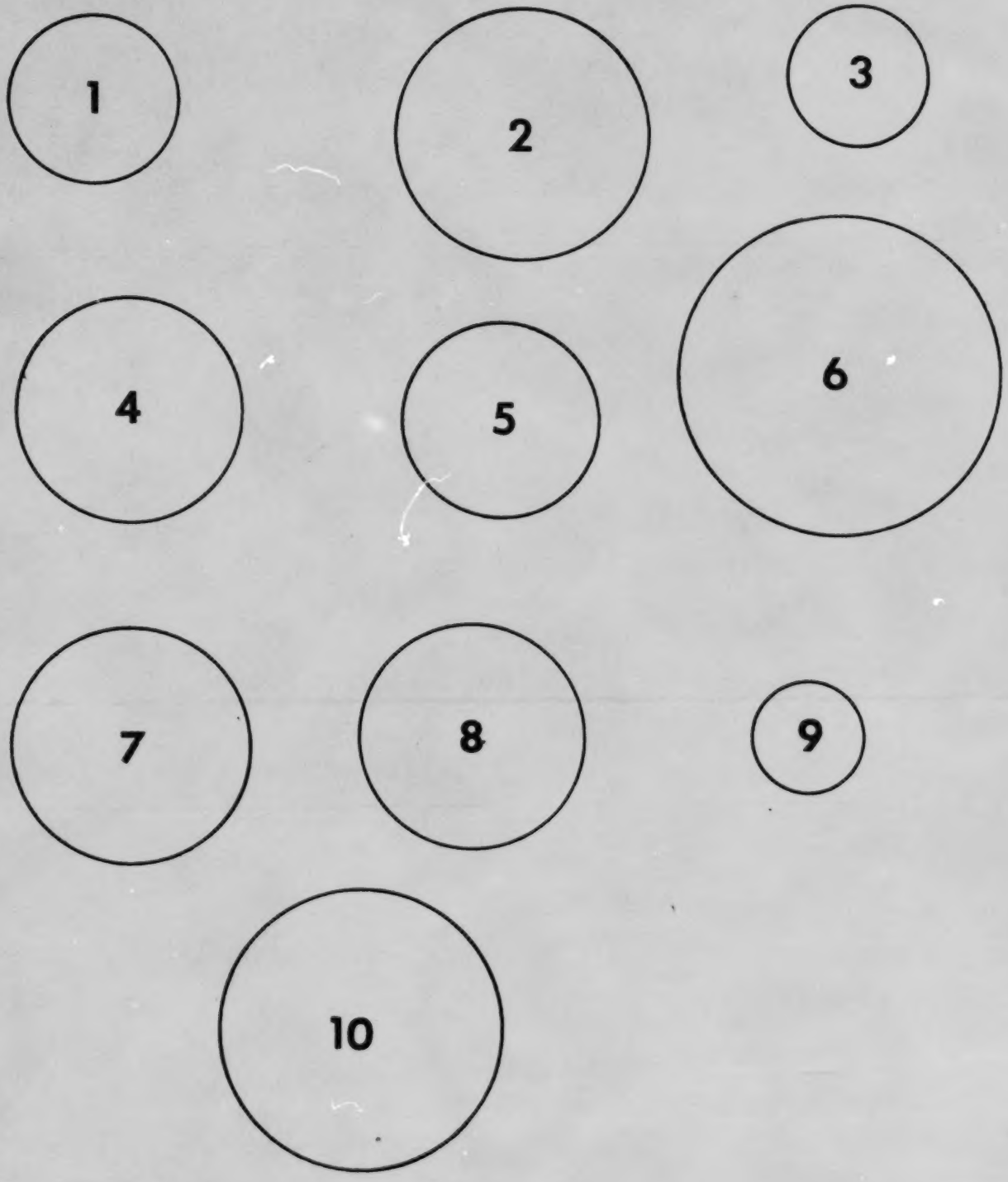
CIRCLE TEMPLATE



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SQUARING THE CIRCLE

TASK: To find the area, in square centimetres, of a circle by using a balance

ACTIVITY:

A. 1. Using the compass, ruler, and very sharp pencil, draw a circle with radius 10 centimetres on a sheet of graph paper.

2. Cut out the circle very carefully.

3. Using the balance, find the area of the circle using the technique used to find the area of an elephant in the activity TRUNK AREA.

4. On the CIRCLE AREA WORKSHEET, record the information asked for about this circle (called Circle A).

B. Repeat Part A for each circle whose radius is listed on the CIRCLE AREA WORKSHEET.

C. 1. When you've filled in all cells of the CIRCLE AREA WORKSHEET, examine that data to find a reasonable formula which will allow you to predict the area (in square centimetres) of a circle when you know the radius (in centimetres). What is that formula?

2. Use your formula to predict the area of a circle with a radius of 8 centimetres. Check your estimate (and formula) by using the balance.

EXTENSION: Using sample ellipses, try to find a formula for the area of an ellipse.

MATERIALS:
Compasses
Ruler marked in centimetres
Several sheets of square-centimetre graph paper
Scissors
Balance
Copies of CIRCLE AREA WORKSHEET

* *

NOTES:

(a) The purpose of Parts A-C is to suggest a reasonable formula for area A of a circle with radius r. Within the experimental errors inherent to the method, a good formula is:

$$A = 3 \cdot r \cdot r \text{ (or } A = 3r^2\text{)}$$

(b) Students must work very carefully to get data good enough to generate the formula in NOTE (a). It is unreasonable to expect data that would come closer to the actual formula. However, the formula in NOTE (a) gives good approximations and is easy to use. Students should be told that there is a "better" formula, but that this one gives useful approximations.

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CIRCLE AREA WORKSHEET

Circle	RADIUS OF CIRCLE (in centimetres)	AREA OF CIRCLE (in square centimetres)	SQUARE OF RADIUS OF CIRCLE (multiply radius measure times itself)
A	10		
B	5		
C	9		
D	7		
E	6		

126

127

TRI A RECTANGLE

TASK: To produce, by estimation, rectangles and triangles having a given area (in square centimetres)

ACTIVITY:

A. 1. Without measuring, cut out a rectangle which is not a square and which has an area of about 100 square centimetres.

2. Use the plastic grid to check the area of your rectangle.

   a. If you are "off" by 20 square centimetres or more, throw away the rectangle and try again.

   b. Keep trying until you are "off" by less than 20 square centimetres.

B. 1. Without measuring, cut out a nonsquare rectangle which has an area of about 150 square centimetres.

2. Use the plastic grid to check the area of the rectangle.

3. Keep trying until you are "off" by less than 30 square centimetres.

C. 1. Without measuring, cut out a triangle which has an area of about 50 square centimetres. (Your work in Part A should help here.)

2. Check your estimate. Keep trying until you are off by less than 5 square centimetres.

D. 1. Without measuring, cut out a triangle with an area c 80 square centimetres.

2. Check your estimate. Keep trying until you are off by less than 10 square centimetres.

MATERIALS: Paper
Scissors
Plastic square-centimetre grid
Balance and square-centimetre graph paper (see NOTE)

* *

NOTE: Of course, the students could use a balance and graph paper to check the area (as in TRUNK AREA or SQUARING THE CIRCLE).

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TEMP-TEMP, WHAT'S THE TEMP?

TASK: To find the temperature(s) of a room

ACTIVITY: People often speak of <u>the</u> temperature of a room. In this activity we'll investigate the question of whether temperature is the same everywhere in a room.

1. Several thermometers, with colored tags, have been placed in this room. Make a list of the locations of the thermometers.

2. Record the temperature at each location.

3. Does the room have a single temperature? If not, what are the highest and lowest temperatures? What temperature occurs most often? What is the hottest location? What is the coolest location? If you were going to report <u>the</u> temperature of the room, what would you say?

MATERIALS: 8-12 Celsius thermometers
Masking tape
String
Colored tags

* *

NOTES: (a) It's best to do this activity on a sunny day.

(b) Place thermometers in several locations throughout a room, including such locations as a place near a window, near a heater (if it's on), near a door, in the center of the room, in the front of the room, in the rear of the room, near the floor, near the ciling, near an incandescent bulb, near a fluorescent bulb,etc

(c) This activity should be repeated in the same room at different times of the day and on different days. <u>It should also be done in several rooms</u>, where the rooms differ in size, location within the building, etc.

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BOILING POINT

TASK: To find the temperature at which water boils (wherever you are)

ACTIVITY: The purpose of this activity is to find the local boiling point of water. Although some thermometers will indicate on their cases that this temperature is 100 degrees Celsius, the temperature at which water boils is affected by such things as the altitude at which the water is being boiled.

A. Place water to a depth of 5 centimetres in one beaker and heat it until it boils.

B. With the container of water still on the heat source, lower the thermometer into the boiling water and leave it there for at least 2 minutes.

C. If you cannot read the thermometer in the beaker, use the pot holder to grab hold of the hot thermometer, remove it from the water and quickly record the temperature. (Even a few seconds out of the water will cause the thermometer reading to drop. If you have to wait more than 5 seconds to do the reading, put the thermometer back in the water and try again.)

D. Please add water if the water that is boiling is getting low, but add slowly.

EXTENSION: The boiling point of water changes with altitude. Find out how many degrees Celsius it changes for each 500-metre change in altitude. Find out what change in altitude will result in a change of one degree Celsius.

MATERIALS: Two beakers
Thermometer (must go to 100 degrees Celsius)
Heat source
Water
Pot holder

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SUMMER IN LARAMIE

TASK: To identify the temperature at which ice melts

ACTIVITY:

1. Fill the container about one-fourth full of cool tap water.
2. Add enough ice (cracked ice, if possible) to read about the three-fourths level of the container.
3. Using a stirring rod (but not the thermometer), stir the ice-water mixture for about 3 minutes.
4. Now place the thermometer in the mixture of melting ice; allow it to remain there for 3 minutes, stirring once each minute.
5. Remove the thermometer and quickly read the temperature. (If you wait more than 10 seconds or if you touch the bulb at the bottom of the thermometer, the reading will be incorrect. If this happens, return the thermometer to the melting ice for another 3 minutes.)

MATERIALS: Glass beaker (a small bowl or drinking glass will do)
Ice
Ice cracker (or hammer and old towel)
Celsius thermometer

* *

NOTE: The directions in Parts 3-5 are quite specific. It might be worth having students conjecture the reasons for such conditions as "not the thermometer," "stir...about 3 minutes," "remain...3 minutes," "stirring once each minute," "10 seconds" and "touch the bulb,"

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TASK: To identify your normal (underarm) body temperature

ACTIVITY: The purpose of this activity is to identify your normal (underarm) body temperature--that is, the temperature when you are "at rest." If you've been doing hard work or play, wait at least 15 minutes before doing this activity.

1. Place a thermometer under your arm with the bulb resting against your skin. Hold it there for at least 3 minutes by pressing your arm against your side.

2. Remove the thermometer and read it quickly. If you wait more than 5 seconds before you read it, the air temperature will have changed the reading. If this happens, replace the thermometer under your arm and begin again.

EXTENSION: Plan to take your underarm temperature under other conditions, such as after 5, 10, and 15 minutes of exercise.

MATERIALS: Thermometers

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HOW'S THE WEATHER?

TASK: To sample outdoor temperatures

ACTIVITY: Radio and television newsmen tell us of the changes in outdoor temperature from day to day. They also usually report a high temperature and a low temperature for a given day. A few newsmen will even tell you where the temperature readings were taken (at the studio, a local airport, etc.). In this activity we'll investigate the effects of day, time and location upon temperature reports.

A. 1. Place thermometers in several locations outdoors. Be certain to include the following locations:

   eye-level in the sun
   eye-level in the shade

   Other possible locations would be on the grass, on a sidewalk or on a tar surface. (You think of some.)

2. On a copy of the Outdoor Temperatures Report Form, describe each location where you've placed a thermometer.

3. Decide on the times during the day when you will read the thermometer. Enter these times in the Report Form.

4. Date the Report Form.

5. On the Report Form, describe what kind of day it is: sunny, raining, cloudy, snowing, etc.

6. At each chosen time, read each of the thermometers and record the temperature in degrees Celsius.

7. At the end of the day, record the high and low temperatures for the day and the times at which they occurred.

B. Repeat this activity for several days. Check your "highs" and "lows" against those reported by local radio stations.

MATERIALS: Several thermometers
Copies of the Outdoor Temperature Report Form

* *

NOTE: This is valuable as an extended activity. Consider graphing and otherwise summarizing the data. (Include at least 1 week per month--better yet, 5 random days per month.)

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OUTDOOR TEMPERATURES REPORT FORM

DATE: _____ KIND OF DAY: _____

LOCATION OF THERMOMETER	Time of Day			
eye-level in the sun				
eye-level in the shade				

High temperature for the day: _____ Time of high: _____

Low temperature for the day: _____ Time of low: _____

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I'LL DRINK TO THAT

TASK: To identify the temperatures of common items

ACTIVITY:

1. Do at least three other activities before doing this one. (One must not celebrate too early.)
2. Are you sure you did 3 other activities? Read the rest of this activity before doing any part of it.
3. By now you are probably thirsty. Find a water fountain and get a drink of water, estimate the temperature, then check your estimate.
4. It's been a long day, so to stay awake, have a drink of coffee, tea, or other hot beverage, estimate the temperature of it, then check your estimate.
5. Proceed to the pop machine and check the temperature on the inside and outside of the machine, but make sure you estimate it first. If you decide to indulge, estimate and check the temperature of the pop.
6. If you followed the directions given in 2 above, be on your way.

MATERIALS:
Thermometers
Pop machine
Source of water
Source of coffee, tea, etc.

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COOL, COOL WATER

TASK: To find the bottom temperature in your comfort-range of temperatures

ACTIVITY: The purpose of this activity is to identify the temperature of the coldest water in which you would find it comfortable to go swimming.

1. Put about a litre of tap water in a bucket.

2. Place a thermometer in the bucket.

3. Test the temperature of the water in the bucket (for personal comfort) using your elbow. If you find that the water is TOO COLD for swimming, slowly add hot water until the water in the bucket is barely warm enough for you to be willing to swim in it. Wait about 3 minutes and then read the temperature of this barely-warm-enough water.

   If the water in the bucket ever has a temperature which is higher than that which you consider barely warm enough for swimming, slowly add ice water to adjust it. When you reach the barely-warm-enough situation, wait 3 minutes before recording the temperature.

4. PLEASE EMPTY YOUR BUCKET OF SWIMMING WATER BEFORE GOING TO ANOTHER ACTIVITY.

MATERIALS:
Water
Hot water source
Bucket
Thermometer
Ice

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SATURDAY NIGHT

TASK: To find the top temperature in your comfort-range of temperatures

ACTIVITY: The purpose of this activity is to identify the temperature of the hottest water in which you would be willing to take a bath.

1. Put a thermometer in the bottom of an empty bucket.

2. Add about a litre of tap water to the bucket.

3. Test the temperature of the water in the bucket (for personal comfort) using your elbow.

If you find that the water in the bucket is TOO HOT for a bath, slowly add ice water until the water in the bucket is tolerable (barely) for a bath--that is, it is the hottest water in which you would be willing to take a bath.

If the water in the bucket ever reaches a temperature which is below the hottest bath water you can tolerate, slowly and boiling water to adjust it.

When the water has reached the temperature which you feel is the hottest bath water you can tolerate, wait 3 minutes and then record that temperature.

4. PLEASE EMPTY OUT YOUR BUCKET OF BATH WATER BEFORE GOING ON TO ANOTHER ACTIVITY.

MATERIALS:
Water
Bucket
Ice
Thermometer
Hot water source

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WEATHER YOU LIKE...AND OTHER TEMPERATURES OF INTEREST

TASK: To identify the temperatures associated with common events

ACTIVITY: The purpose of this activity is to become familiar with the temperatures associated with things we do almost every day. In some cases, a single temperature can be associated with an event; in other cases, a range of temperatures makes a more meaningful association.

A few sample events are listed below. Find the temperatures associated with these and identify other common events which have a temperature that you can measure.

A. The temperature at which you (or a friend) would prefer to drink a hot drink. (It is the temperature of the drink, not the day, that's of interest here.)

B. The temperature at which you prefer to drink a cold drink. (Again, it is the temperature of the liquid that's of interest.)

C. A comfortable room temperature.

D. The temperature of a "nice" day.

E. The temperature of a "hot" day.

F. The temperature of a "cold" day.

G. _____

H. _____

I. _____

Identify some other temperature-related events of interest to you.

MATERIALS: Thermometers

* *

NOTE: In the case of Parts D - F, students may have to wait for convenient days to take these temperatures.

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COOL IT

TASK: To determine how cold you can make a water-ice or a water-ice-salt mixture

ACTIVITY: This activity will take 10 minutes.

A. Place 50 millilitres of water in each of two beakers and place a thermometer in each.

B. To one beaker, start adding ice, and to the other beaker, add ice and salt. Note the temperature of each.

C. Repeat Step C until you can't get the water-ice and water-ice-salt mixtures any colder.

D. Compare your answer in (C) to those found by others in the group.

MATERIALS: Two glass beakers (about 500 millilitres each)
Water
Salt
Ice
Ice-cracker (or hammer and old towel)
Two thermometers
Two stirring instruments

* *

NOTE: One might wish to relate this information to the technique used in making homemade ice cream. Better yet, find two comparable ice cream freezers and try freezing one with ice and the other with ice-salt mixture.

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SALTY

TASK: To examine the effect upon the boiling point of water of adding salt to it.

ACTIVITY: It takes at least 15 minutes to do this activity correctly. Take your time.

As you work, keep these 2 warnings in mind:

NEVER stir the solution with the thermometer
DON'T let the thermometer touch the container.

1. Wash the graduated beaker with clear, warm water. Be certain that it's free of salt before you go on.
2. Measure 500 millilitres of water into a cooking container and bring it to a rolling boil. Record the temperature of the water.
3. Add 15 millilitres of salt to the water. Stir the solution until all of the salt is dissolved (the solution is clear) and the solution is again at a rolling boil. Record the temperature of this solution on your chart after the '15.'
4. Add another 15 millilitres of salt to the water. Stir until the salt is dissolved and the solution is again boiling, and record the temperature of this solution after the '30' in your chart.
5. Continue to add salt (15 millilitres at a time) and to record the boiling temperature of the new solution each time until you reach a point where no more salt will dissolve (the solution remains cloudy or a deposit of salt remains on the bottom of the container).
6. Discuss the results recorded in your chart.
7. PLEASE TURN OFF THE HEAT SOURCE AND (USING THE OVEN MITTS) EMPTY OUT YOUR SOLUTION OF SALT WATER.

EXTENSION: Repeat the activity, using sugar in place of salt.

MATERIALS:
Water
Salt
Glass beaker
Oven mitt
Teaspoon
Copies of SALTY WORKSHEET

Sugar (for EXTENSION)

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SALTY WORKSHEET

millilitres of salt (500 millilitres of water)	boiling temperature (in degrees Celsius)

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DIRTY WORK

TASK: To find the temperature of the soil

ACTIVITY: Using the materials provided, go outside and find 2 or more places to record soil temperatures, leaving the thermometer in the ground for 5 minutes.

MATERIALS: Small digger
Thermometers

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MATCHING, PLANTING, FISHING

TASK: To explore temperatures in other environments

ACTIVITY: Certain forms of classroom living things survive at temperatures different from the regular classroom temperature.

As directed by your instructor, look for thermometers in an aquarium, incubator, plant house, or other environment, and record the temperatures you find.

1. aquarium: Tropical fish live in water with a Celsius temperature of _____.

2. incubator: Hatching eggs need a Celsius temperature of _____.

3. plant house: Young plants grow ideally at a temperature of _____.

4. other environments: Identify other environments and find the environmental temperatures. (Consider the environments of worms, pond plants and fish, bread yeast, etc.)

MATERIALS: Three Celsius thermometers
Aquarium
Incubator
Plant house

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I'LL TAKE THE LITTLE RED JOB

TASK: To pick a comfortable color for a car

ACTIVITY:

A.
1. In each plastic bag, place one thermometer and one color of cloth (or paper) and close the bags tightly. Let's call each such package a "car."
2. Place all of the cars in a sunny spot; leave them there for 15 minutes.
3. Make a list of the different colors of cars that you've made.
4. When 15 minutes have passed, begin to take the car temperatures one at a time. Do each reading quickly (10 seconds or less) or it could be incorrect.

B.
1. Discuss the results of Part A.
2. What car colors would you recommend for someone who lives in Alaska?
3. What car colors would you recommend for someone who lives in Galveston, Texas?
4. What car colors would seem to be best for someone in your town?

MATERIALS:
8-12 pieces of colored cloth or construction paper
8-12 thermometers
8-12 zip-lock or twist-tie clear plastic bags

* *

NOTE: Of course you could use real cars if they're available.

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THE SWIMMIN' HOLE

TASK: To find the temperature of the water in a swimming pool

ACTIVITY:

A. The instructor will inform you as to where you can find a swimming pool. Your task is to use a thermometer and to determine the temperature(s) of the water in the pool.

B. Place the thermometer in different locations and at different depths in the pool. Keep a record of the locations and temperatures.

MATERIALS:

Swimming pool
Thermometers
String
Some metre sticks
Masking tape

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UPSY-DOWNSY

TASK: To check temperature change caused by chemical reaction

ACTIVITY: Place about 50 millilitres of water at room temperature into a beaker and check the water temperature.

A. Put 5 millilitres of material from bottle A into one beaker and 5 millilitres of material from bottle B into the other beaker.

B. Check the temperature of each mixture.

C. Surprised?

D. Can you explain what happened?

MATERIALS:
2 beakers
2 thermometers
Calcium chloride
Postassium nitrate
5-millilitre measure
Water

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TEMPERATURES RISING

TASK: To find out how air temperature varies with height

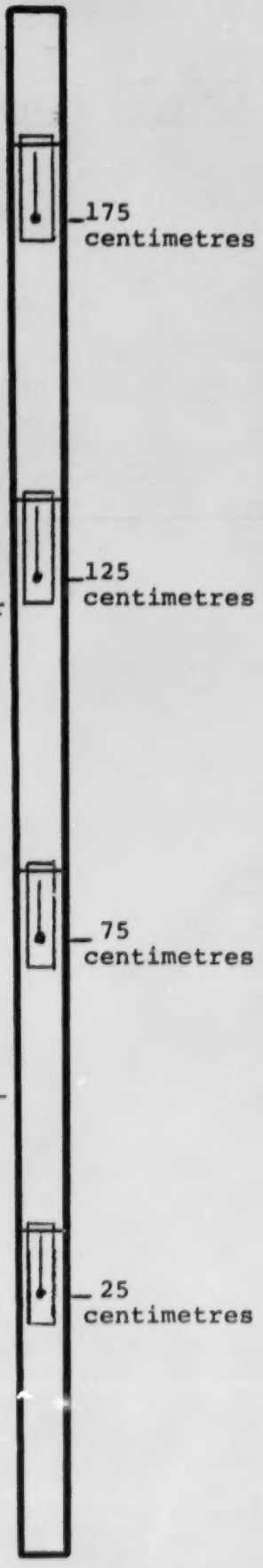
ACTIVITY: In other activities you found that temperature varied according to the location in which the thermometer was placed, whether inside or out. This activity will look for changes in temperature at different heights above each of several surfaces.

A. 1. Tape 4 of the 5 thermometers to a stick as shown in the picture. (The bulb of the first thermometer should be 25 centimetres from the bottom of the stick, the bulb of the second thermometer should be 75 centimetres from the bottom of the stick, etc.)

B. 1. Place the extra thermometer on the floor of your classroom and hold the stick up next to it.
2. Wait 5 minutes.
3. On a VERTICAL TEMPERATURES CHART, describe the location as 'over classroom floor'.
4. On the chart, record the temperatures on each of the five thermometers.

C. 1. Choose some locations outside. Write a description of each location on a VERTICAL TEMPERATURES CHART. (Some possible locations are over grass and facing the sun, over grass and facing away from the sun, over a sidewalk, over sand, over tar, etc.)
2. For each location, follow the procedure of Part B.

MATERIALS:
5 Celsius thermometers
Stick about two metres long
Masking tape
A watch
Copies of VERTICAL TEMPERATURES CHART



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VERTICAL TEMPERATURES CHART

Location _____

Height Above Surface (in centimetres)	Temp
0	
25	
75	
125	
175	

Location _____

Height Above Surface (in centimetres)	Temp
0	
25	
75	
125	
175	

Location _____

Height Above Surface (in centimetres)	Temp
0	
25	
75	
125	
175	

Location _____

Height Above Surface (in centimetres)	Temp
0	
25	
75	
125	
175	

Location _____

Height Above Surface (in centimetres)	Temp
0	
25	
75	
125	
175	

Location _____

Height Above Surface (in centimetres)	Temp
0	
25	
75	
125	
175	

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TAKE A DIP

TASK: To check your ability to estimate water temperatures

ACTIVITY: In other activities, you have learned several "reference temperatures." That is, you should now know your body temperature, the approximate temperature of this room, the temperature of comfortable bath water, etc. The purpose of this activity is to have you put that knowledge to work as you try to estimate the temperature of each of several water samples.

Each bucket contains a sample of water at a certain temperature; a thermometer has been placed FACE DOWN on the bottom of each bucket (so that you can check your estimate later.)

1. Each bucket has been labeled with a letter of the alphabet. On a sheet of paper, make a list of those letters used.
2. After your list of letters, make a chart with two columns Head one column "My Estimate;" head the other column "Correct Temperature."
3. Choose a bucket; remove the lid and dip your elbow in the water. Write your estimate of the water temperature in the appropriate place under "My Estimate" on your chart. Replace the lid.
4. Repeat Part 3 for each bucket.
5. When everyone has completed his temperature estimates, check those estimates by having someone read the thermometers in the buckets.

MATERIALS:
4-6 small styrofoam buckets with lids
4-6 Celsius thermometers
Hot water
Ice
Paper towels

* *

NOTE: With the help of ice and hot water, adjust the temperature of the water in the buckets to different temperatures between 0 degrees Celsius and 55 degrees Celsius. (To be tricky, have two buckets with the same water temperature.) It would be a good idea to include 0 degrees Celsius (melting point of ice), 20 degrees Celsius (nationally recommended room temperature), 35 degrees Celsius (near body temperature) and 55 degrees Celsius (near top of comfort range). Let sit 15 minutes before using and check; the mass of the styrofoam often alters the temperatures. Adjust just before using.

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ON THE BEACH

TASK: To investigate the "cooling effect" of being wet

ACTIVITY: When you come out of the water when swimming on a windy day, you may suddenly feel cold. You probably heard that this is due to the evaporation of the water on your body. In this exercise we will assume that you have been swimming in room temperature water and investigate the change in temperature due to evaporation. We'll also look at the temperature change that you could expect if you'd been swimming in room temperature alcohol!

A. 1. Allow a container of rubbing alcohol and a container of water to stand until each is at room temperature. (Check by placing thermometers in the liquids; keep the bulbs immersed until both show the same reading.)
   2. Using a piece of tape, place the label 'WATER' on one of the thermometers, 'ALCOHOL' on another and 'DRY' on the last.
   3. Tie a wad of dry cotton on the thermometer labeled 'WATER' and 'ALCOHOL.'
   4. Place all three thermometers in front of the fan and turn it on. After 3 minutes, turn off the fan and record the reading on each thermometer.

B. 1. Dip the cotton of the thermometer labeled 'ALCOHOL' in the alcohol; dip the cotton of the thermometer labeled 'WATER' in the water.
   2. Place all three thermometers where the air is calm. (You may have to put them under a box or something.)
   3. After 3 minutes, record the reading on each thermometer.

C. 1. Again dip the two thermometers as you did in Item 1 of Part B.
   2. Turn on the fan and hold all three thermometers in front of it for 3 minutes.
   3. Record the lowest reading that you see on each thermometer during the 3-minute period.

D. From the information gathered in Parts A-C, order the following four situations from warmest to coldest.

   After swimming in water, step out onto a windy beach.
   After swimming in water, step out onto a still beach (no wind).
   After swimming in alcohol, step out onto a windy beach
   After swimming in alcohol, step out onto a still beach (no wind).

EXTENSION: Experiment with other liquids such as ammonia, liquid bleach, cleaning fluids, etc.

MATERIALS:

A1 electric fan (or a windy day)	3 Celsius thermometer
Some cotton	String
Water at room temperature	Rubbing alcohol
1 or 2 classmates	

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A SENSE OF COOL

TASK: To test your sensitivity to differences in temperature

ACTIVITY: In the activity ON THE BEACH, you investigated the "cooling effects" of alcohol and water. In this activity, you'll test your ability to feel the difference between those effects.

A. 1. Suppose you dipped one hand in water, the other hand in alcohol and then held both hands in the breeze of a fan. Which hand should feel cooler?
   2. Check your answer to Item 1 by looking at the results you got in ON THE BEACH.

B. Now let's test your ability to feel this difference.

   1. Blindfold one partner.
   2. Have the blindfolded partner hold out his hands with his palms up.
   3. Dip one cotton ball in water and another cotton ball in alcohol.
   4. The two persons who are not blindfolded should now rub alcohol on one wrist (of the blindfolded partner) and water on the other wrist. DO NOT LET THE BLINDFOLDED PERSON MOVE HIS WRISTS OR STAND IN A BREEZE!
   5. Within 5 seconds, the blindfolded person must tell you which wrist has water and which has alcohol. Record what he says and what was actually the case in a chart like this one.

Actual Situation		Situation Reported (by blindfolded partner)	
Right Wrist	Left Wrist	Right Wrist	Left Wrist
Water	Alcohol		
Alcohol	Water		
Water	Alcohol		

   6. Repeat Step 5 several times. Keep changing the actual situation.
   7. Blindfold a different partner and repeat Steps 1-6 using a different set of actual situations.

C. Repeat Part B for each partner, but this time have the blindfolded person place his wrists <u>in front of a running electric fan</u> as soon as they are wet.

MATERIALS: Teams of three persons
A blindfold
Rubbing alcohol (room temperature)
Cotton
An electric fan
Water (room temperature)

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IN HONOR OF ANDERS

TASK: To make a Celsius thermometer

ACTIVITY: Anders Celsius (1701-1744) designed the temperature scale which now bears his name. In this activity you'll follow a relatively simple procedure, like the one he used, beginning with a blank thermomometer attached to a piece of backing material.

A. 1. Place several ice cubes (broken, if possible) in a small bowl. Add 50 millilitres of cool tap water and stir for 3 minutes with a stirring rod.
   2. Hold the bulb of your thermometer in the ice water; keep the backing material above the bulb out of the ice water. Keep it there for 3 to 5 minutes (or until the fluid in the thermometer has stopped moving downward).
   3. Without removing the thermometer bulb from the ice water, make a mark on the backing material to show where the fluid has stopped.
   4. Remove the thermometer, dry it, and write '0' next to the mark you just made. (Celsius also assigned '0' to the melting point of ice.)

B. 1. Place the thermometer under your arm with the bulb against your skin. Hold it there for at least three minutes (or until the fluid in the thermometer has stopped rising).
   2. Without removing the bulb from under your arm (if possible) or working as quickly as possible, make a mark on the backing material to show where the fluid stopped.
   3. Write a '35' next to the mark you just made. (Although your underarm temperature may be close to 37 degrees Celsius, we can use 35 as a good approximation this choice also helps make further calibration easier

C. Working carefully, locate points along the thermometer which correspond to temperatures from -10 degrees Celsius to 50 degrees Celsius. Make a mark for (at least) every interval of 5 degrees Celsius.

D. Use your thermometer to take the temperature of common events you've worked with in earlier exercises.

E. Check the accuracy of your thermometer by measuring those same events using a commercial Celsius thermometer.

MATERIALS: A blank thermometer mounted on plastic or tagboard
Ice, water, and a small bowl
Marking pen (or grease pencil with sharp point)
Celsius thermometer (HOLD UNTIL PART E!)

* *

NOTES: (a) Many school science kits contain blank thermometers. Check with your science department.

(b) In Part B, we establish body temperature as the second scale point and assign it the number 35. Historically, Anders Celsius used the boiling point of water and assigned it the number 100. Our choice is based on the fact that most blank thermometers have an upper temperature bound of about 55 degrees Celsius.

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SECOND COURSE:

TEACHER SUPPORT MATERIALS

EXCERPTS FROM METRIC CONVERSION ACT OF 1975

Public Law 94-168

Signed by President Gerald Ford on December 23, 1975

"A bill to declare a national policy of coordinating the increasing use of the metric system in the United States and to establish a United States Metric Board to coordinate the voluntary conversion to the metric system."

Defines "Metric System of Measurement" - SEC.4. (4) "metric system of measurement" means the International System of Units as established by the General Conference of Weights and Measures in 1960 and as interpreted or modified for the United States by the Secretary of Commerce.

Establishes the United States Metric Board - SEC.5. (a) There is established, in accordance with this section, an independent instrumentality to be known as a United States Metric Board. (b) The Board shall consist of 17 individuals, as follows:

(1) the Chairman, a qualified individual who shall be appointed by the President, by and with the advice and consent of the Senate;
(2) sixteen members who shall be appointed by the President, by and with the advice and consent of the Senate, on the following basis --

(A) one to be selected from lists of qualified individuals recommended by engineers and organizations representative of engineering interests;
(B) one to be selected from lists of qualified individuals recommended by scientists, the scientific and technical community, and organizations representative of scientists and technicians;
(C) one to be selected from a list of qualified individuals recommended by the National Association of Manufacturers or its successor;
(D) one to be selected from lists of qualified individuals recommended by the United States Chamber of Commerce, or its successor, retailers, and other commercial organizations;
(E) two to be selected from lists of qualified individuals recommended by the American Federation of Labor and Congress of Industrial organizations or its successor, who are representative of workers directly affected by metric conversion, and by other organizations representing labor;
(F) one to be selected from a list of qualified individuals recommended by the National Governors Conference, the National Council of State Legislatures, and organizations representative of State and local governments;
(G) two to be selected from lists of qualified individuals recommended by organizations representative of small business;
(H) one to be selected from lists of qualified individuals representative of the construction industry;
(I) one to be selected from a list of qualified individuals recommended by the National Conference on Weights and Measures and standards making organizations;
(J) one to be selected from lists of qualified individuals recommended by educators, the educational community, and organizations representative of educational interests; and,
(K) four at-large members to represent consumers and other interests deemed suitable by the President and who shall be qualified individuals.

As used in this subsection, each "list" shall include the names of at least three individuals for each applicable vacancy. The terms of office of the members of the Board first taking office shall expire as designated by the

President at the time of nomination; five at the end of the 2nd year; five at the end of the 4th year; and six at the end of the 6th year. The term of office of the Chairman of such Board shall be 6 years. Members, including the Chairman, may be appointed to an additional term of 6 years, in the same manner as the original appointment. Successors to members of such Board shall be appointed in the same manner as the original members and shall have terms of office expiring 6 years from the date of expiration of the terms for which their predecessors were appointed. Any individual appointed to fill a vacancy occurring prior to the expiration of any term of office shall be appointed for the remainder of that term. Beginning 45 days after the date of incorporation of the Board, six members of such Board shall constitute a quorum for the transaction of any function of the Board.

(c) Unless otherwise provided by the Congress, the Board shall have no compulsory powers. (d) The Board shall cease to exist when the Congress, by law, determines that its mission has been accomplished.

Specifies Functions of the Board - SEC.6. It shall be the function of the Board to devise and carry out a broad program of planning, coordination, and public education, consistent with other national policy and interests, with the aim of implementing the policy set forth in this Act. In carrying out this program, the Board shall --

(1) consult with and take into account the interests, views, and conversion costs of United States commerce and industry, including small business; science; engineering; labor; education; consumers; government agencies at the Federal, State and local level; nationally recognized standards developing and coordinating organizations; metric conversion planning and coordinating groups and such other individuals or groups as are considered appropriate by the Board to the carrying out of the purposes of this Act. The Board shall take into account activities underway in the private and public sectors, so as not to duplicate unnecessarily such activities;

(2) provide for appropriate procedures whereby various groups, under the auspices of the Board, may formulate, and recommend or suggest, to the Board specific programs for coordinating conversion in each industry and segment thereof and specific dimensions and configurations in the metric system and in other measurements for general use. Such programs, dimensions, and configurations shall be consistent with (A) the needs, interests, and capabilities of manufacturers (large and small), suppliers, labor, consumers, educators, and other interested groups, and (B) the national interest;

(3) publicize, in an appropriate manner, proposed programs and provide an opportunity for interested groups or individuals to submit comments on such programs. At the request of interested parties, the Board, in its descretion, may hold hearings with regard to such programs. Such comments and hearings may be considered by the Board;

(4) encourage activities of standardization organizations to develop or revise, as rapidly as practicable, engineering standards on a metric measurement basis, and to take advantage of opportunities to promote (A) rationalization or simplification of relationships, (B) improvements of design, (C) reduction of size variations, (D) increases in economy, and (E) where feasible, the efficient use of energy and the conservation of natural resources;

(5) encourage the retention, in new metric language standards, of those United States engineering designs, practices, and conventions that are internationally accepted or that embody superior technology;

(6) consult and cooperate with foreign governments, and intergovernmental organizations, in collaboration with the Department of State, and, through appropriate member bodies, with private international organizations, wich are or become concerned with the encouragement and coordination of increased use of metric measurement units or engineering standards based on such units, or both. Such consultation shall include efforts, where appropriate, to gain international recognition for metric standards proposed by the United States, and, during the United States conversion, to encourage retention of equivalent customary units, usually by way of dual dimensions, in international standards or recommendations;

(7) assist the public through information and education programs, to become familiar with the meaning and applicability of metric terms and measures in daily life. Such programs shall include --

(A) public information programs conducted by the Board, through the use of newspapers, magazines, radio, television, and other media, and through talks before appropriate citizens' groups, and trade and public organizations;

(B) counseling and consultation by the Secretary of Health, Education, and Welfare; the Secretary of Labor; the Administrator of the Small Business Administration; and the Director of the National Science Foundation, with educational associations, State and local educational agencies labor education committees, apprentice training committees, and other interested groups, in order to assure (i) that the metric system of measure ment is included in the curriculum of the Nation's educational institutions and (ii) that teachers and other appropriate personnel are properly trained to teach the metric system of measurement;

(C) consultation by the Secretary of Commerce with the National Conference of Weights and Measures in order to assure that State and local weights and measures officials are (i) appropriately involved in metric conversion activities and (ii) assisted in their efforts to bring about timely amendments to weights and measures laws; and

(D) such other public information activities, by any Federal gency in support of this Act, as relate to the mission of such agency;

(8) collect, analyze, and publish information about the extent of usage of metric measurements; evaluate the costs and benefits of metric usage; and make efforts to minimize any adverse effects resulting from increasing metric usage;

(9) conduct research, including appropriate surveys; publish the results of such research; and recommend to the Congress and to the President such action as may be appropriate to deal with any unresolved problems, issues, and questions associated with metric conversion, or usage, such problems, issues, and questions may include, but are not limited to, the impact on workers (such as costs of tools and training) and on different occupations and industries, possible increased costs to consumers, the impact on society and the economy, effects on small business, the impact on the international trade position of the United States, the appropriateness of and methods for using procurement by the Federal Government as a means to effect conversion to the metric system, the proper conversion or transition period in particular sectors of society, and consequences for national defense;

(10) submit annually to the Congress and to the President a report on its activities. Each such report shall include a status report on the conversion process as well as projections for the conversion process. Such report may include recommendations covering any legislation or

executive action needed to implement the programs of conversion accepted by the Board. The Board may also submit such other reports and recommendations as it deems necessary; and,

(11) submit to the Congress and to the President, not later than 1 year after the date of enactment of the Act authorizing appropriations for this Act, a report on the need to provide an affective structural mechanism for converting customary units to metric units in statutes, regulations, and other laws at all levels of government, on a coordinated and timely basis, in response to voluntary conversion programs adopted and implemented by various sectors of society under the auspices and with the approval of the Board. If the Board determines that such a need exists, such report shall include recommendations as to appropriate and effective means for establishing and implementing such a mechanism.

THE INTERNATIONAL SYSTEM OF UNITS (SI)

(Units, Prefixes, Symbols)

The International System of Units (SI), sometimes called the Metric System, is presently used by about 90 per cent of the world's population. The United States, conspicuous as the last major nation to hold onto the English or Customary System of Measurement, is now moving toward the adoption of SI. Industry and scientific research have led the way; education is now making definite plans to make SI the fundamental measurement system in the public schools.

We are, in a way, adopting a new language. Inasmuch as this will be no small task, it seems clear that the job should be done correctly the first time. In reading the literature and instructional materials regarding SI, however, one encounters various claims as to what constitutes the SI units, assorted spellings of the names of the units and their prefixes, and numerous abbreviations or symbols for units in the system. The purpose of this paper is to set these matters straight, based upon the agreements published by such sources as the Metric Association, Inc. It will also set forth certain educational recommendations found in the above sources as well as in publications of the National Council of Teachers of Mathematics and the National Council of State Supervisors of Mathematics.

Three Classes of SI Units

There are three classes of SI units: base units, derived units and supplementary units. The seven base units are the metre (length), kilogram (mass), kelvin (temperature), second (time), ampere (electric current), mole (amount of substance) and candela (luminous intensity). Several derived units are formed from combining these basic units. Among the derived units are the square metre (area), cubic metre (volume), newton (force), joule (work) and watt (power). The supplementary units consist of the radian (plane angle measure), the steradian (solid angle measure) and units derived by combining these two units with other base units of derived units.

In addition to these official SI units, there are certain units outside of SI which are used with it. These are discussed below.

Units Outside of SI

There are certain units which, while outside of SI, are related to SI units. Because these outside units are important and widely used, they will continue to be used -- some more or less permanently and others for the time being. Among those outside units which would seem to be destined for long life are the hour (time), hectare (area), degree (angle measure), litre (volume), minute (both time and angle measure), second (both time and angle measure), day (time), tonne (mass), knot (speed), and degree Celsius (temperature). These non-SI units are approved for use along with SI units.

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Outside units of a more temporary status include the bar (pressure) and roentgen (radiation exposure).

Disapproved Units

Certain units of measure have been designated as obsolete or as marked for obsolescence in the near future. In addition to the yard, pound, tablespoon, degree Fahrenheit and related units, these disapproved units include the degree centigrade (temperature), standard atmosphere (pressure), millilitre of mercury (pressure), calorie (energy) and are (area).

Multiples and Sub-multiples of Units

Basic to SI is that all multiples and sub-multiples are decimal (i.e., powers of 10). Six prefixes indicating multiples and eight prefixes indicating submultiples have been adopted. They are:

Prefix	Phonic	Factor	Symbol
exa	ex'a	10^{18}	E
peta	pet'a	10^{15}	P
tera	ter'a	10^{12}	T
giga	ji'ga	10^{9}	G
mega	meg'a	10^{6}	M
kilo	kil'o	10^{3}	k
hecto	hek'to	10^{2}	h
deka	dek'a	10^{1}	da
deci	des'i	10^{-1}	d
centi	sen'ti	10^{-2}	c
milli	mil'i	10^{-3}	m
micro	mi'kro	10^{-6}	u
nano	nan'o	10^{-9}	n
pico	pe'ko	10^{-12}	p
femto	fem'to	10^{-15}	f
atto	at'to	10^{-18}	a

Note that only the symbols for exa (E), peta (P), tera (T), giga (G) and mega (M) are capitalized. More will be said about this later.

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SI Units Everyone Should Know

The next several pages give detailed information about those SI base units, SI derived units and approved non-SI units which should be familiar to everyone. Of the base units, only the metre and kilogram appear; the kelvin is replaced by the more common non-SI unit, degree Celsius. Although the other four base units (second ampere, mole and candela) will certainly be of concern to students of the sciences, they are not considered to be of sufficiently everyday use to be discussed here. (This decision of the writer is supported by educational recommendations of both the National Council of Teachers of Mathematics and the National Bureau of Standards.) The supplementary unit, radian, is also defined.

In writing the detailed discussions of units which follow, certain conventions were employed. The reader should be aware of the following:

1. With one exception, tables displaying the multiples and submultiples of a unit employ only six of the 16 prefixes noted earlier. These six prefixes (kilo, hecto, deka, deci, centi, milli) are judged to cover all of the multiples and submultiples of practical use to most people.

2. The ending 're' is used rather than 'er' (e.g., metre rather than meter). This is in keeping with the international spelling agreements.

3. The name for any measure is followed by the symbol for that measure enclosed in parentheses. For example:

   metre (m)
   kilogram (kg)
   Degree Celsius (°C)

4. In any chart, the SI unit for the quantity under discussion will be enclosed in a box. For example:

metre (m)

5. In cases where non-SI units are in common use, charts indicate their equivalence to SI units. Of course, such are approved for use with SI.

6. Many of the multiples and submultiples of a given unit will be of little practical use to most people. Underlining has been used to indicate those measures which should be of practical use and, hence, should be taught.

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7. Because it can often be difficult to distinguish the typed numeral for one (1) from the symbol for litre (the lower case letter 'l'), the script 'ℓ' has been used for 'litre.' (If a typewriter doesn't have an 'ℓ,' it is general practice to spell out 'litre.') Symbols for multiples and submultiples of the litre cause no problems. Thus, we write

ℓ for litre

but

ml for millilitre
kl for kilolitre

A Final First Warning

This document contains information believed to represent the true state of affairs as of April of 1977. It does not claim to present eternal truths.

International conferences on metric matters have been convening since 1875; significant changes in SI were made by such groups as late as 1971 when the mole (a base unit for measuring the amount of substance) was adopted. Like the English language, SI is a living thing. It is subject to additions, deletions and rule changes as time passes and experience dictates the need for change.

Neither panic nor be discouraged. The fact is that the system is probably ninety-nine and forty-four one hundredths per cent developed; future changes will most likely affect only those folks working at the lunatic fringe of science.

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LENGTH

The SI unit of length is the metre (m). This is a base unit; SI units of area and volume are derived from it.

By definition, the metre is 1 650 763.73 wavelengths (in vacuum) of the orange-red line of the spectrum of the krypton 86 atom. As fascinating as that definition may be, it is meaningless to anyone without a substantial science background and is not something that should be memorized (in vacuum) for regurgitation on tests, etc.

A chart of useful multiples and sub-multiples of the metre (with appropriate symbols) is given below.*

Measure	Symbol
kilometre	km
hectometre	hm
dekametre	dam
metre	m
decimetre	dm
centimetre	cm
millimetre	mm

*Those multiples and sub-multiples judged to be of practical use to most people have been underlined.

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AREA

The SI unit of area, a derived unit, is the square metre (m^2). The hectare (100 ares or 10 000 square metres) is still used in measuring land, but the square metre (along with its multiples and sub-multiples) will be used for most work.

The following chart shows certain multiples and sub-multiples of the square metre along with the equivalent hectare.*

SI Units		Approved Non-SI Units	
Measure	Symbol	Measure	Symbol
square kilometre	km^2		
square hectometre	hm^2	hectare	ha
square metre	m^2		
square decimetre	dm^2		
square centimetre	cm^2		
square millimetre	mm^2		

*Those multiples and sub-multiples judged to be of practical use to most people have been underlined.

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VOLUME

The SI unit of volume, a derived unit, is the cubic metre (m^3). One sub-multiple, the cubic decimetre (dm^3), is of great practical use, it is often called by its non-SI name litre (ℓ).

The chart below shows the multiples and sub-multiples of the SI unit as well as the corresponding non-SI units in terms of litres. The litre (and certain of its multiples and sub-multiples) is frequently used in measuring the volumes of liquids and gasses but is by no means confined to measuring liquids and gases. Both units are used for measuring volumes of any kind.

The "holes" in the chart indicate that certain equivalent measures do not have special names or are not in common use.*

SI Units		Approved Non-SI Units	
Measure	Symbol	Measure	Symbol
cubic kilometre	km^3		
cubic hectometre	hm^3		
cubic dekametre	dam^3		
cubic metre	m^3	kilolitre	kl
		hectolitre	hl
		dekalitre	dal
cubic decimetre	dm^3	litre	ℓ
		decilitre	dl
cubic centimetre	cm^3	centilitre	cl
		millilitre	ml
cubic millimetre	mm^3		

* Those multiples and sub-multiples judged to be of practical use to most people have been underlined.

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MASS

The SI unit of mass is the kilogram (km). The kilogram is a base unit; it is the only base unit which has a prefix.

The kilogram is unique among SI base units since it is only one still calibrated from a prototype. That prototype is a cylinder of platinum-iridium alloy which is kept at the Bureau of Weights and Measures in Paris. The United States has a duplicate cylinder at its own Bureau of Weights and Measures.

The kilogram is a measure of mass, not weight. Weight is a force; the SI unit of force, derived from the base units metre, kilogram and second, is the newton (N). The term 'weight' should not be used when mass is intended. If the kilogram is the measure unit being employed, the quantity being measured is mass.

A chart of mass measures follows. Because it is of practical use, the megagram (1000 kilograms) is included. It is perhaps more commonly known by the non-SI name tonne (t) or metric ton (t).*

Measure	Symbol
megagram (tonne)	Mg(t)
.	
.	
.	
kilogram	kg
hectogram	hg
dekagram	dag
gram	g
decigram	dg
centigram	cg
milligram	mg

* Those multiples and sub-multiples judged to be of practical use to most people have been underlined.

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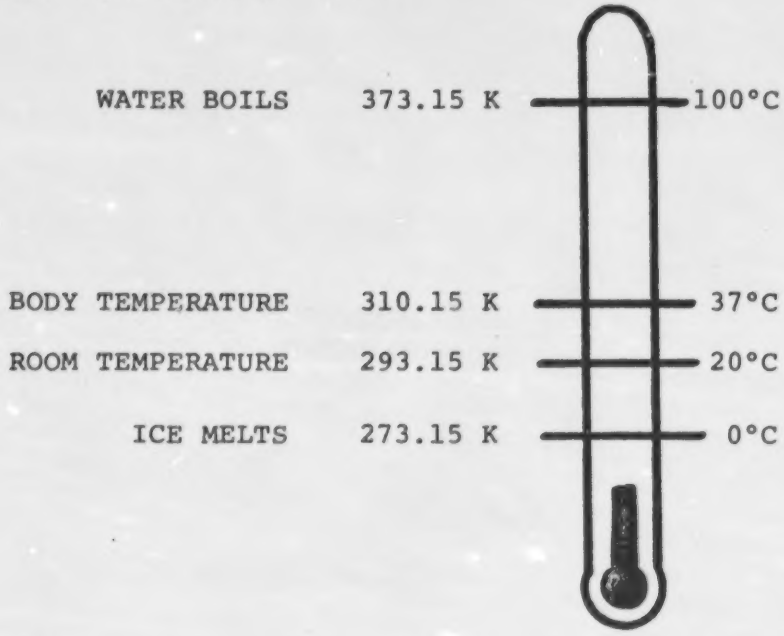
TEMPERATURE

The SI unit of temperature is the kelvin (K). Ice melts at 273.15 K and water boils at 373.15 K, assuming distilled water at sea level; the lowest temperature possible is zero K and is called absolute zero.

Although the kelvin is the SI base unit for temperature and will be employed in scientific and technical fields, the common unit of temperature will be the non-SI unit called the degree Celsius (°C). The degree intervals on the Celsius scale are the same as on the kelvin scale; a Celsius reading is, however, always 273.15 less than the corresponding kelvin reading. Thus ice melts at 0°C and water boils at 100°C; absolute zero is -273.15°C. The diagram below shows a few corresponding points of the two scales.



There are two important things for the educator to note with respect to measuring temperature.

1. Apart from advanced courses in science, it is the degree Celsius that will be used to measure temperature.
2. The common non-SI unit should be called 'degree Celsius' and not 'degree centigrade.' The phrase 'degree centigrade' is no longer associated with temperature because of confusion with the 'degree centigrade' which denotes an angle measure (one hundredth part of a right angle, or grade) in some metric countries.
3. The "boiling point," usually associated 100°C, is a function of pressure or altitude. Whereas water boils at 100°C in Miami, Florida, it will boil at only 93°C in Laramie, Wyoming.

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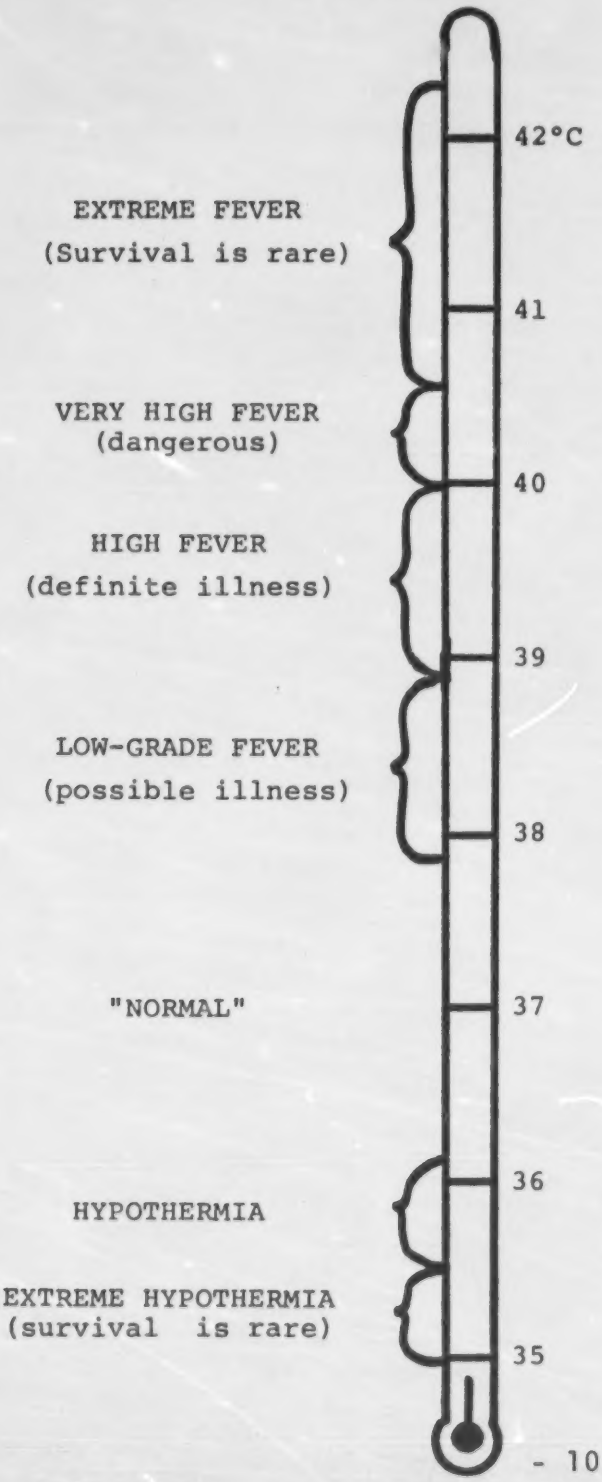
One further bit of information about temperature is with regard to the range of human body temperature. Since hospital thermometers will soon be marked in degrees Celsius, the following illustration may prove useful.

HUMAN BODY TEMPERATURES*
(Oral)



* The ranges given are averages, of course. What may be a low-grade fever for someone in generally good health could be a high or dangerous fever for someone who is in a generally weakened condition.

Also, the ranges are for adults. Young children may quite normally show temperatures which are 0.5 to 0.6 degrees Celsius higher.

Rectal temperatures will normally run 1 degree Celsius higher than oral temperatures.

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PLANE ANGLES

The SI Unit for measuring plane angles is the radian (rad). This supplemental SI unit is preferred over both the degree and the grade, the latter being the non-SI unit used in some metric countries.

By definition, the radian is the central angle subtended by an arc of length r on a circle of radius r. Since the length of the circumference of a circle is $2\pi r$, it follows that there are 2π radians in a complete revolution.

A circular protractor based upon the radian might look like this:

The angle measures below correspond to the multiples of the angle measures of the triangle obtained by bisecting an angle on an equilateral triangle and are most useful in trigonometry.

$\frac{\pi}{6}$ rad $\quad$ $\frac{\pi}{3}$ rad $\quad$ $\frac{2\pi}{3}$ rad $\quad$ $\frac{5\pi}{6}$ rad

$\frac{7\pi}{6}$ rad $\quad$ $\frac{4\pi}{3}$ rad $\quad$ $\frac{5\pi}{3}$rad $\quad$ $\frac{11\pi}{6}$ rad

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Other Useful Units and Symbols

The preceding pages deal with the SI and non-SI units which are of import to most persons and which are probably not well known yet. Other SI units will be used by restricted groups; some familiar non-SI units will continue to be used. The charts below give the names of these units, the correct symbol for each unit and indicate the quantity that each unit is used to measure.

Some Other SI Units

	Quantity Measured	Unit	Symbol
base units	time	second	s
	electric current	ampere	A
	amount of substance	mole	mol
	luminous intensity	candela	cd
derived units	force	newton	N
	work	joule	J
	power	watt	W
	frequency	hertz	Hz
	pressure	pascal	Pa

Some Familiar Approved Non-SI Units

Quantity	Unit	Symbol
time	minute	min
time	hour	h
time	day	d
angles	degree	°
angles	minute	'
angles	second	"

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The units in the second chart involve the nondecimal multiples and submultiples we have known so long (60 min = 1 h, 24 h = 1 d, 360° = one complete revolution, 60' = 1°, and 60" = 1'). However, decimal subdivision of the degree is preferred to the use of the minutes and seconds; thus 28.25° is preferred to 28°15'36".

Rules for Writing Metric

As in any language, there are precise rules for capitalization, punctuation and abbreviation when using the language of SI measure. One of these (the substitution of spaces for commas in writing about large numbers or small decimal fractions) affects all arithmetic computation, not just when dealing with measures. In use for many years in Europe, it is new--and relatively unknown--in the United States. However, it is a style which (1) is part of SI measure and (2) has been recommended to the American Association of Publishers by 25 states which use state adoption procedures in selecting mathematics textbooks. Need more be said?

1. Non-SI Units. The use of non-SI units should be confined to those used to measure time (day, hour), temperature (degree Celsius rather than the kelvin), volume (litre) and angle (the degree-minute-second system or the grade as well as the radian).

2. Endings: 're' Versus 'er'. In keeping with international agreements, 're' is preferred to 'er'. (For example, metre, litre and centimetre.)

3. Punctuation. Measures in SI have names that are shortened by using symbols rather than abbreviations. Symbols are not followed by periods (except when they occur at the end of a sentence) whereas abbreviations often include periods. Thus we write:

   kg dal cm^2 °C m^3

   but not:

   kg. dal. $cm.^2$ °C. $m.^3$

4. Plurals. The full, written names for the plural of SI measures are constructed in the usual way as specified by the English teacher down the hall. However, the SI symbols are always written in singular form. Thus we write:

   mm g rad s

   but not:

   mms gs rads ss

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(d) If exactly four digits lie to the left or right of the decimal point, the spacing is optional. (However, commas still are not to be used.) For example:

4539 or 4 539 but not 4,539
1689.4813 or 1 689.481 3 but not 1,689.4813
either 0.3885 or 0.388 5 is correct

8. Separation of Numerals and Units. With the exception of the symbols for degree Celsius and the symbols for degree, minute and second (associated with the approved non-SI units of plane angle measure), there is always a space to separate a symbol from the numerical value. Thus we have:

2.38 m rather than 2.38m
5.061 kg rather than 5.061kg

and, in the case of the exceptions, we have:

37°C rather than 37 °C
28°14'29" rather than 28° 14' 29"

9. Derived Units. This is a three-part rule, the first part of which is of use to everyone. The other two parts will be of interest to secondary school teachers of mathematics or science.

(a) The oblique stroke (/) or a horizontal line may be used to express a derived unit formed by division. For example:

88 kilometres per hour is 88km/h or 88 $\frac{\text{km}}{\text{h}}$

6.05 grams per square centimetre is 6.05 g/cm^2 or 6.05 $\frac{\text{g}}{\text{cm}^2}$

(b) The product of two or more units is preferably indicated by a dot. A space is also acceptable and, when there is no risk of confusion with another symbol, both dot and space may be omitted. For example:

A kilogram metre per second squared may be written:

$\text{kg}\cdot\text{m/s}^2$ or $\frac{\text{kg m}}{\text{s}^2}$ or $\frac{\text{kgm}}{\text{s}^2}$

A metre gram per second squared may be written:

$\text{m}\cdot\text{g/s}^2$ or $\frac{\text{m g}}{\text{s}^2}$. but not: $\frac{\text{mg}}{\text{s}^2}$

since the latter symbol may be confused with milligram per second squared.

(c) Negative exponents also may be used to express derived units which are formed by division. For example:

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kilogram per cubic metre is $kg \cdot m^{-3}$

grams per square centimetre is $g \cdot m^{-2}$

litres per second is $\ell \cdot s^{-1}$

References

In preparing this paper, use was made of newsletters from the Metric Association, Inc., the National Council of State Supervisors of Mathematics and the National Council of Teachers of Mathematics. Other major references included:

Hopkins, R.A., The International (SI) Metric System and How It Works, second edition (revised). AMJ Publishing Company, Tarzana, California, 1974

Interstate Consortium on Metric Education, Final Report, California State Department of Education, Sacramento, 1975

Metric Units of Measure and Style Guide, U. S. Metric Association, Inc., Boulder, Colorado, 1976

USMA Metric Practice Committee, Metric Units of Measure and Style Guide, eleventh edition (revised), U. S. Metric Association, Inc., Boulder, Colorado, 1976

U.S. National Bureau of Standards, A Metric America: A Decision Whose Time Has Come. U. S. Department of Commerce, NBS Special Publication 345, Government Printing Office, Washington, 1971

-----, U. S. Metric Study Interim Report: Education. U. S. Department of Commerce, NBS Special Publication 345-6, Government Printing Office, Washington, 1971.

Science teachers may wish to obtain a copy of the reference by R. A. Hopkins since it provided carefully organized information on SI, approved non-SI and outdated unit names and symbols of scientific measures. The reference from the U.S. Metric Association would, on the other hand, be of greatest use to those outside the weird world of science.

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METRIC RECOMMENDATION

OF

28-STATE CONSORTIUM ON METRIC EDUCATION

Credit Where Credit is Due

In 1974, representatives of 28 states (and territories)* addressed themselves to 23 issues regarding metric education. Because copies of the final report of that group (Interstate Consortium on Metric Education Final Report, California State Department of Education, Sacramento, 1975) are no longer available, the Science and Mathematics Teaching Center has prepared the following summary. The summary contains the statement of the 23 recommendations; the last page of the summary shows the final voting on each of these recommendations by each state or territory of the Interstate Consortium on Metric Education (ICME).

The 23 Recommendations

1. The Interstate Consortium on Metric Education (ICME) recommends that the International System of Units (SI) be the standard units of measurement used in all instructional programs.

2. The ICME recommends that for matters concerning definition of units, style, and spelling that the International System of Units (SI), as stated in the U.S. Department of Commerce publication NBS 330 and the American Society for Testing and Materials publication E 380-72, be used in the preparation of instructional materials.

   Note: Although there has been no national consensus on the spelling of the base unit of length, the ICME prefers the spelling metre. Additionally, the preferred spelling for the unit of capacity is litre.

   In common practice, the word weight means either mass or force. The ICME prefers that the word weight and its derivatives (weigh, weighing, and so forth) be avoided in instructional programs.

3. The ICME recommends that during the period of transition from the U.S. Customary system of measurement to the metric system of measurement that provision be made for the inclusion of metric materials commensurate with the achievement and maturity of the students. The scope should be sufficiently broad and sequenced in a manner to facilitate student development to a level of performance normally expected at appropriate (various) maturity levels.

4. The ICME recommends that instructional materials, to reflect a genuine concern for how and when children learn to measure, follow

*See the chart on the last page of this document for a listing of the participating states and territories.

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an appropriate sequence: (a) comparison between objects; (b) comparing nonstandard units with objects; (c) comparing objects to be measured with SI units; (d) choosing measurement units of appropriate size for specific tasks.

5. The ICME recommends that activity oriented measurement experiences for children be planned to include the following learning processes: language development, estimation and verification, simple matching and comparison, ordering, simple relations and mapping, and pictorial representations.

6. The ICME recommends that all prefixes in the range milli- to kilo- be presented to illustrate the logical structure of the metric system. However, commonly used units should be emphasized in learning activities and are underlined below.

millimetre	millilitre	milligram
centimetre	centilitre	centigram
decimetre	decilitre	decigram
metre	litre	gram
dekametre	dekalitre	dekagram
hectometre	hectolitre	hectogram
kilometre	kilolitre	kilogram

Two commonly used terms which do not incorporate commonly used pre fixes are "cubic decimetre" (dm^3) and "hectare" (ha). The cubic decimetre should be used to show the relationship between linear measure and volume; the square kilometre and/or the hectare are used as the units for large land areas.

7. The ICME recommends that the recording of measurements within SI be accomplished in decimal notation.

8. The ICME recommends that the conversion process between the International System of Units (SI) and oth r systems of units be avoided. In disciplines in which conversion is presently relevant and required, appropriate information should be made available so that the use of conversion formulas will not be required.

9. The ICME recommends that in the pronunciation of metric prefixes the accent be placed on the first syllable.

10. The ICME recommends that effort be made to ensure that metrication be realized through integration of the International System of Units (SI) throughout the school curriculum and that the metric system not be presented as an isolated topic of study.

Note: It is dangerous to the educational process when any curricular strand or subcomponent of a strand is singled out of context for special emphasis. If so treated, metrics could easily become identified as a special or limited subject. It is the intent of this recommendation that metrics not be identified as a special subject.

11. The ICME recommends that evaluative criteria for the adoption of instructional materials include the pertinent recommendations of the consortium.

12. The ICME recommends that metric-awareness programs for the public and intensive inservice programs for school personnel precede adoption of metric educational materials.

13. The ICME recommends that state educational agencies encourage teacher-education institutions to begin immediately to include opportunities for students to develop competencies in using and teaching the metric system.

14. The ICME recommends that by January 1, 1978, state educational agencies include in their evaluative criteria for adoption of instructional materials the pertinent recommendations of this report.

15. The ICME recommends that during the adoption cycle of the transition period that state educational agencies encourage local educational agencies to provide instructional materials to supplement textbooks that have little or no metric measurement content.

16. The ICME recommends that January 1, 1980, be the target date for the completion of the transition to the metric system in textbooks and other instructional materials; the ICME recognizes that certain vocational/technical timelines may be bound to related industrial conversion.

17. The ICME recommends that coordinated state efforts be made to inform and involve business, industry, and other organizations in the transition to SI metrics. A broad, multifaceted public-awareness program should be undertaken and should include but not be limited to the following:

    - Publication of metric information in state-agency, teacher-association, and other professional journals and publications
    - Inclusion of metric sessions in the meetings of professional organizations
    - Encouragement of television stations to present programs and public-service announcements about the metric system
    - Encouragement of libraries and instructional-material centers within the state to obtain metric related materials
    - Establishment of communication channels to provide information about the metric system and assistance to local educational agencies in implementing public relations programs in metric education
    - Encouragement of and assistance to local educational agencies in efforts to inform and involve parents in the transition to the metric system

18. The ICME recommends that state educational agencies encourage formative evaluation to determine proper placement for metric measurement activities

19. The ICME recommends that preservice and/or inservice education programs be designed to prepare elementary teachers, administrators, and support personnel involved in instruction to implement measurement using metric units. The recommended program includes two areas of concern: (a) metric awareness; and (b) metric measurement experiences for teachers and aides.

20. The ICME recommends that preservice and/or inservice training programs for teachers at the secondary school level (grades seven through twelve) be designed to help these teachers become aware of the basic content and learning principles used in the elementary metric programs. In addition, secondary training programs should contain more concentrated, in-depth treatment of measurement for teachers in specialized areas. These specialized areas are: (a) vocational/technical education, including industrial arts, home economics, and related fields; and (d) mathematics and science.

21. The ICME recommends that state educational agencies provide leadership by developing a core of resource personnel whose responsibility will be to implement metric education programs at the local level.

    Note: The need for implementing a variety of metric education programs at the local level necessitates the training of resource personnel who can carry out these programs effectively. A core of resource personnel could be trained and then in turn train others to assist in implementing metric education programs all the way to the local school level.

22. The ICME recommends that measurement inservice programs for individuals directly involved in teaching measurement to students be of 10 to 16 hou s' duration. Introductory inservice programs of 3 to 6 hours' duration on metric measurement should be designed for all individuals involved in instruction. In both programs, "hands-on" activities should be emphasized.

23. The ICME recommends that (a) mathematics and science teachers assume the major responsibility for teaching the metric system; and (b) teachers in all subject areas assume the responsibility for teaching applications of the metric system.

    Note: Teaching the metric system is a multidisciplinary concern.

Final Voting of ICME on 23 Recommendations

The next--and final--page of this summary is a reproduction of the voting chart which appeared on Page 21 of the ICME Final Report.

FINAL VOTING ON ICME RECOMMENDATIONS

STATE	RECOMMENDATION																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Alabama																							
American Samoa																							
Arizona		X	X				X																
Arkansas																							
California																							
Dist. of Col.		A																					
Florida																							
Georgia																							
Guam																							
Hawaii																							
Idaho																							
Indiana																							
Kentucky																							
Louisiana							X																
Mississippi																							
Nevada																						X	
New Mexico																							
N. Carolina																							
N. Dakota																							
Oklahoma																							
Oregon																							
Puerto Rico																							
S. Carolina		X																					
Tennessee																							
Texas												X		X	X	X					X	X	
Utah																							
Virginia		X				X									X								
W. Virginia																							

KEY TO VOTING

X - No
  - Yes
A - Abstention

*Two of the three votes cast against Recommendation 2 reflected the concern of those participants (Arizona and Virginia) about the legality in their respective states of recommending a commercial publication (ASIM publication E 386-72) for use as a guide in preparing instructional materials. The third "no" vote (South Carolina) was cast because the state considered the weight-mass issue received too little discussion in the rationale.

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BUDGETING FOR METRICATION
June, 1977

Purpose of this Paper

The information in this document was gathered at the request of school systems preparing to begin the teaching of SI (metric) units of measure as the primary units of measure. Because it is believed that teaching should be activity-based, providing students of all ages with many opportunities to use metric measuring instruments in problem-solving or information-gathering situations, school systems wished (1) to identify basic nontext equipment needed by a classroom unit, (2) to receive suggestions regarding where quality items can be purchased and (3) to identify items which can or should be made by teachers rather than purchased. The attached pages are an attempt to meet these three needs.

Limitations of this Effort

The Science and Mathematics Teaching Center has experimented with items of equipment in doing metrication activities; it continues to sample new equipment as it becomes available and to expand and test its list of activities. The suggestions which follow are, then, a product of its experience to date.

No attention is given here to textbooks, workbooks, duplicator masters, films, cassettes, slides or filmstrips. These materials are appearing on the market at an ever-increasing rate and are being gathered by the Center, but any attempt at review would be folly. The purchase of such support materials would depend greatly upon a system's present holdings, the age level of students, teaching ob-

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jectives and teaching style. Moreover, much we have seen is of poor quality and misses the whole point of the national objective to teach people to think metric.

Notes About What Follows

The remainder of this paper consists of four items.

1. A list of BASIC EQUIPMENT FOR TEACHING METRICATION. This list gives the quantity of items to which each teacher should have access. Of course, several of the items might be shared.

2. A list of PUBLISHING HOUSES from which certain items of the preceding list can be purchased. While schools may wish to purchase from other companies, the brochures of these companies allow us to describe, simply and precisely, the features of each item we feel is needed.

   If you wish a recent and rather complete list of metric suppliers, write to the National Council of Teachers of Mathematics (1906 Association Drive, Reston, VA 22091) and request a copy of the NCTM METRICATION UPDATE & GUIDE TO SUPPLIERS OF METRIC MATERIALS.

3. A collection of RANDOM NOTES about the items to be purchased. These notes point out those characteristics of certain items under BASIC EQUIPMENT which our experience has revealed are educationally significant but which might not be so recognized by someone who has not used the materials. The notes allow us to offer options about what should be purchased, what should be made by teachers, what items should be in every classroom, what items might be shared, etc.

4. Brief directions on how to construct recommended TEACHER-MADE MATERIALS.

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BASIC EQUIPMENT FOR TEACHING METRICATION

The following equipment list indicates the quantity and source of "special" items to which each classroom teacher should have access. There are also lots of items (square-centimetre paper, plastic cups, old containers of all sorts, masking tape, marking pens, etc.) which are necessary but are not listed here because they can usually be made, collected, borrowed or swiped from local sources.

The Roman numerals in parentheses after each item indicate a supply house (see list on next page) where a good quality version of the item may be purchased. A good first move would be to request a full brochure from each company so that you can see the items and check current prices. Also, read RANDOM NOTES before doing any purchasing.

LENGTH and AREA

A. 10 plain (unmarked) metre sticks--(teacher-made)
B. 5 decimetre-band metre sticks--(teacher-made)
C. 5 centimetre-band metre sticks--(teacher-made)
D. 10 20-centimetre rulers--(teacher-made)
E. 10 cloth centimetre-band measuring tapes--(teacher-made)
F. 1 height-chart--(teacher-made)
G. 100 orange Cuisenaire rods--(I)
H. 1000 white Cuisenaire rods--(I)
I. 2 plastic (wood doesn't work well) metric trundle wheels with rubber edges--(V) or (VII)
J. 2 centimetre-square plastic grids--(II)
K. 1 metric wall chart--(III)

VOLUME, MASS and TEMPERATURE

L. 1 set plastic measuring cylinders--(II)
M. 4 plastic buckets (about 8-litre)--(local stores)
N. 1 cubic metre frame--(II)
O. 1 personal scale (metric)--(II)
P. 100 Cube-O-Gram masses--(IV)
Q. 1 set metric masses--(II)*
R. 1 Ohaus Model 1200-50 School Balance (without masses)--(IV)

or

S. 5 Celsius (only) thermometers (temperature range from -20°C to 110°C)--(VI)

*NOTE: The set of masses needed is not sold as a prepacked set. It must be put together by selecting the correct number of masses of each of several sizes. The masses making up this set are specified in RANDOM NOTE II on Page 6 of this paper.

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*PUBLISHING HOUSES
(Sources of Metric Supplies)

I. Cuisenaire Company of America, 12 Church Street, New Rochelle, New York, 10805

II. Dick Blick Company, PO Box 1267, Galesburg, Illinois 61401

III. Ideal School Supply Company, 11000 South Lavergne Avenue, Oak Lawn, Illinois 60453

IV. Ohaus Scale Corporation, 29 Hanover Road, Florham Park, New Jersey 07932

V. Creative Publications, Inc., PO Box 10328, Palo Alto, California 94303

VI. Xerox Educational Group, 555 Gotham Parkway, Carlstandt, New Jersey 07072

** VII. ENRICH, Inc., 760 Kifer Road, Sunnyvale, California 94086

* Write to each, requesting a brochure which includes all metric education supplies; also try to get the name of the representative serving your region as this speeds up the ordering process.

** Somewhat of a "new kid" in the metric marketplace, ENRICH has distinguished itself by producing materials which adhere strictly to SI.

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RANDOM NOTES

(Information About Basic Metrication Equipment)

These notes give information concerning the 20 items (A-T) of BASIC EQUIPMENT listed earlier. Although our selection is based upon experience, the selections represent opinions and should be treated as such.

1. Items A-F. These items should be in every classroom. All of these items can be purchased, but the cost seems excessive for such simple devices.

   Items B and C (especially B) are very hard to find in catalogs, yet these are the types of devices needed by persons who are learning the basic features of the metric system of length. Conversely, the metre stick usually found in classrooms (graduated to millimetres) is too refined for most elementary children and too sophisticated for anyone just learning the system. We advise against the use of the latter instrument for teaching linear measure.

2. Items G and H. These are also useful in many activities about volume.

3. Item I. Be certain to get the plastic wheel (specify METRIC) with a rubber edge. The wooden wheels slip on many surfaces, causing large errors in measurement.

4. Item J. The centimetre-square grids are excellent for approximating areas. There is also a millimetre-square grid for finer work, but young students are "put off" by the extra work required. The square-centimetre is, moreover, a more practical small unit of area.

5. Item K. Most charts concentrate on teaching conversion; this one does not. It gives excellent, full-sized pictures of the metric units involved and restricts itself to teaching about metric measures.

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6. Item L. These could be shared by teachers. They are necessary for many activities. Made of plastic, they should have long life.

7. Item M. Get these locally in a discount store (An 8-litre bucket will, by the way, hold a little more than 2 gallons.)

8. Item N. This may seem an extravagence, but volume is a difficult concept. We tried making our own frame and found (1) it's a job and (2) it costs about as much to make as to buy.

9. Item O. Every elementary classroom should have one. Be certain it's marked in kilograms only!

10. Item P. These are really useful. Not only is each cube a model of a millilitre (cubic centimetre) but also each has a mass of one gram! They are the only such cubes on the market which are 1-gram masses. They are excellent one gram masses and can be joined to form other small masses up to 10 grams.

11. Item Q. A basic set of masses--some cast iron and some brass "coin" masses--can be put together from the selections available from Dick Blick. The set should contain the following:

Quantity	Item
1	1000-gram (cast iron)
1	500-gram (cast iron)
5	100-gram (cast iron)
2	50-gram (brass)
5	20-gram (brass)
10	10-gram (brass)

12. Item R. Chances are that the school's science supplies will include this item. There is also a good chance that you can locate cheaper balances, but the Ohaus balance (which could be shared) is a worthwhile investment.

13. Item S. It is difficult to find thermometers which (1) have the Celsius scale only, (2) have a large enough temperature range to be useful in classroom activities, and (3) are mounted within a strong plastic case. Xerox is one of the few outfits which produces a thermometer satisfying all three conditions. However, they also make many thermometers which do NOT satisfy one or both of

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these conditions, so be certain that your order specifies Celsius scale only and temperature range from -20°C to +110°C. For many activities, it also would be nice to have a couple of Celsius laboratory thermometers from Ideal (III) and a cookery thermometer from Blick (II).

*TEACHER-MADE MATERIALS

Some of the following items are not readily available in the United States; all are grossly overpriced when they can be obtained from commercial outfits.

1. Plain metre sticks. Just cut up 3/4-inch screen molding which can be purchased in 16-foot lengths.
2. Decimetre-band metre sticks. Cover the face of a plain metre stick with 3/4-inch black, plastic electrical tape. Cut 1-decimetre lengths of 3/4-inch yellow plastic tape (3M makes it) and place it atop the black tape, leaving 1-decimetre intervals of black. (This color scheme is rather effective.) Do NOT put any numerals on the stick.
3. Centimetre-band metre sticks. Creative Publications (see PUBLISHING HOUSES) markets a roll of self-adhesive vinyl tape with alternating colored centimetre bands along one edge and decimetre bands along the other. Affix this to a plain metre stick (you may have to "trim out" tiny pieces to compensate for stretching of the tape). For longer life, secure it with magic mending tape at 20-centimetre intervals.
4. 20-centimetre rulers. Just use screen molding and the tape of Item 3.
5. Cloth centimetre-band measuring tapes. We just affixed the self-adhesive centimetre tape (see Item 3 above) to ½-inch belting (Belting is a stiff material used by dressmakers as a base for cloth belts.) You may wish to use a softer, more pliable material.

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6. Height chart. There are two possibilities. (a) Put two centimetr band metre sticks end to end and tape them to the wall. (b) Buy a 2-metre length of plain buckram (used in drapes, etc.) and affix self-adhesive centimetre band tape (see Item 3 above).

* Sorry that so many materials in this list must be described with non-metric units of measure. For the moment, however, that's how they are known to most salespersons.

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TESTING A STUDENT'S ABILITY TO "THINK METRIC"

If the purpose of metric education is to produce students who "think metric"--i.e., who are able to make reasonable estimates of length, mass, volume, area and temperature in metric units--tests must be consistent with that purpose. Items such as:

> If 5 inches of rain fall on a field with an area of 6 acres, what is the mass of the total rainfall in (metric) tonnes?

are exercises in conversion, computation and general frustration; moreover, they are far removed from--if not antithetical to--the goal of producing persons whose native tongue is SI. To better define what seems to be needed, two important kinds of tests are attached.

The first five tests give examples of various styles of paper-and-pencil exercises which test the student's gross familiarity with SI units. The student needs only a rough idea of the relative size of the units in order to make reasonable choices on the quizzes for length, mass, volume and area. The temperature quiz, on the other hand, requires that we have built up a store of reference points regarding temperatures.

One variation on the type of testing illustrated in the first four quizzes would test the student's knowledge of the appropriate unit of measure corresponding to a particular quantity to be measured and would have items like:

> An average man has a mass of about 80 (a) centimetres, (b) kilograms, (c) litres.

A second variation on the first four quizzes would present actual objects rather than just naming them. A third variation would be quizzes which are like the one on length but cover several quantities (length, mass, etc.) on a single quiz.

The last quiz is a laboratory style quiz; it is through such a quiz that we can test the ultimate goal: metric estimation (thinking). The two blanks on the quiz should be filled with names of persons (or other large objects). The quiz should be repeated on several occasions using different items. The teacher should establish a range of measures which he will accept as reasonable estimates.

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WHADAYA KNOW ABOUT LENGTH?

For each item below, circle the estimate which is most reasonable.

1. The average height of a basketball player
   (a) 3 cm (b) 2 m (c) 1 dm

2. The height of a ceiling in a home is
   (a) 2.5 m (b) 3.5 cm (c) 4.5 dm

3. The length of a ladybug is
   (a) 4 mm (b) 2 m (c) 3 km

4. The length of a mattress is
   (a) 100 km (b) 150 m (c) 200 cm

5. The waist measurement of a stewardess is
   (a) 65 cm (b) 66 mm (c) 67 m

6. The length of the George Washington Bridge is
   (a) 2000 mm (b) 1065 m (c) 1500 km

7. The length of the Golden Gate Bridge is
   (a) 1.275 km (b) 1275 km (c) 127.5 km

8. The tallest totem pole is
   (a) 89 cm (b) 90 m (c) 91 mm

9. The length of a tall man's foot is
   (a) 30 cm (b) 31 m (c) 32 km

10. The length of a short man's foot is
    (a) 23 m (b) 25 cm (c) 27 km

11. The circumference of a girl's head is
    (a) 55 cm (b) 56 m (c) 57 mm

12. The circumference of a girl's wrist is
    (a) 15 cm (b) 14 m (c) 13 mm

13. The length of a boy's index finger is
    (a) 7.5 cm (b) 7.6 m (c) 7.7 mm

14. The circumference of a friendship ring is
    (a) 50 dm (b) 55 cm (c) 60 mm

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WHADAYA KNOW ABOUT MASS?

Each of the items named below could have its mass measured in terms of milligrams, grams, kilograms or tonnes, but for any item there is one of those four units which is most reasonable. Next to each item, write the name of the unit that seems to be the best unit to use in measuring the item's mass. (Note: For some items, two units are reasonable. Choose the one you think is the better.)

_____ 1. an elephant
_____ 2. a toy balloon
_____ 3. a whole piece of chalk
_____ 4. a person
_____ 5. an apple
_____ 6. a mouse
_____ 7. a pill
_____ 8. a whale
_____ 9. a loaded cement truck
_____ 10. a thumbtack
_____ 11. a turkey
_____ 12. a sheet of notebook paper
_____ 13. a postage stamp
_____ 14. a horse
_____ 15. a package of lunch meat

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WHADAYA KNOW ABOUT VOLUME?

Complete each of the following to get a sensible sentence by writing the name of a unit of volume (millilitre, litre, kilolitre) in the blank.

1. The volume of an average adult man (American) is about 80 _____.
2. The volume of a sugar cube is about 3 _____.
3. An average breakfast serving of orange juice has a volume of about 150 _____.
4. The volume of blood in the average adult (American) is about 4 _____.
5. A garbage can has a volume of about 250 _____.
6. A one-car garage has a volume of about 45 _____.
7. The volume of a basketball is about 10 _____.
8. The volume of a coffee cup is about 200 _____.
9. The volume of the gas tank on a station wagon (full-sized American car) is about 80 _____.
10. The volume of a measuring teaspoon is about 5 _____.
11. The volume of a phone booth is about 2 _____.

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WHADAYA KNOW ABOUT AREA?

For each unit of area below, list five objects for which it would be an appropriate unit to use.

1. square metre

2. square decimetre

3. square kilometre

4. square millimetre

5. square centimetre

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WHADAYA KNOW ABOUT TEMPERATURE?

A. Consider each event described below. Use an 'X' to indicate whether you think the action <u>at the given temperature in degrees Celsius</u> is reasonable or absurd.

Reasonable	Absurd	Event
		1. Go swimming in water that has a temperature of 32 degrees Celsius.
		2. Make a snowman from snow that has a temperature of 10 degrees Celsius.
		3. Go ice skating on a pond when the air temperature is 25 degrees Celsius.
		4. Lie on a beach at 100 degrees Celsius.
		5. Plant lettuce when the air temperature is 25 degrees Celsius.
		6. Wear long-johns when horseback riding at 40 degrees Celsius.
		7. Water your lawn when the air temperature is 18 degrees Celsius.
		8. Run a body temperature of 98.6 degrees Celsius.
		9. Study in a room which has a temperature of 22 degrees Celsius.
		10. Store meat for months at 15 degrees Celsius.
		11. Drink a cup of chicken bouillon which has a temperature of 65 degrees Celsius.
		12. Drink milk which has a temperature of 4 degrees Celsius.

B. For each item you indicated as 'Absurd,' make a note as to why you think it is absurd.

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Name: _____

METRICATION LAB QUIZ

Length, Area, Volume, Mass & Temperature

For each of the following activities, make as accurate an estimate of the measure requested as you can. Make your estimate in terms of the unit of measure indicated.

You may not use formal measuring instruments such as rulers, grids, masses, tapes, etc.--this excludes homemade as well as commercially made instruments.

For each activity you will receive a score of 0, 1 or 2 points according to where your estimate falls with respect to bounds established by your instructor.

_____ 1. Estimate, in decimetres, the length of the electrical cord at this station.

_____ 2. Estimate, in centimetres, the height of _____.

_____ 3. Estimate in metres, the distance between the two pieces of tape on the floor of the hallway outside this room.

_____ 4. Estimate, in square centimetres, the area of the front cover of the booklet at this station.

_____ 5. Estimate in square decimetres, the area of the object at this station.

_____ 6. Estimate in square metres, the area that section of floor which has its corners marked with X's made of tape.

_____ 7. Estimate in litres, the volume of the container at this station.

_____ 8. Estimate, in millilitres, the volume of liquid in the large bottle at this station.

_____ 9. Estimate, in millilitres, the volume of liquid in the small bottle at this station.

_____ 10. Estimate, in grams, the mass of the bag of clay.

_____ 11. Estimate, in kilograms, the mass of _____.

_____ 12. Estimate in degrees Celsius, the temperature of the
_____ 13. water in each bucket. (Be sure to write down the
_____ 14. letter written on each bucket.)

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THIRD COURSE:

CONSTRUCTION ACTIVITIES

MAKE-IT-AND-TAKE-IT
Teacher Activity: Length

GOODIE: A 30-centimetre ruler

HOW TO: A. Cut a 30-centimetre length of wood

B. 1. Place the two-colored vinyl tape on the wood, being careful to start at the beginning of a complete decimetre band.*

2. Use clear plastic tape to secure loose edges.

*BEWARE! Some such vinyl tapes have "spacers" (blanks about 3 centimetres long) inserted after each 50-centimetre interval. This must be removed. Since it often also louses up the pattern of alternating colors in the decimetre bands, you may need to remove one of the decimetre bands as well.

CONSTRUCTION MATERIALS:
Lattice board
Small saw
Commercially produced vinyl metric tape
Clear plastic tape
Scissors
A sample of the finished product

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MAKE-IT-AND-TAKE-IT
Teacher Activity: Length

GOODIE: A metre ruler divided into decimetre bands and centimetre bands

HOW TO: A. Cut a one-metre length of wood.

B. 1. Place the two-colored vinyl tape on the wood, being careful to start at the beginning of a complete decimetre band.*

2. Use clear plastic tape to secure loose edges.

*BEWARE! Some such vinyl tapes have "spacers" (blanks about 3 centimetres long inserted after each 50-centimetre interval. This must be removed. Since it often also louses up the pattern of alternating colors in the decimetre bands, you may need to remove one of the decimetre bands as well.

CONSTRUCTION MATERIALS:
Lattice board
Small saw
Commercially produced vinyl metric tape
Clear plastic tape
Scissors
A sample of the finished product

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MAKE-IT-AND-TAKE-IT

Teacher Activity: Length

GOODIE: Metrically scaled map of your state

HOW TO:

A. 1. Trace the outline of the model map of your state and make dots (through the holes in the model) to mark cities.

2. Label the cities that you marked in Step 1.

B. Using a clear plastic strip and a felt-tipped (indelible ink) pen, copy the "trip strip" -- a kind of ruler which is scaled in kilometres and can be used to estimate the distances between cities in your state. (BE CERTAIN THAT YOU HAVE THE "TRIP STRIP" DESIGNED FOR THE STATE WHOSE MAP YOU'VE DRAWN.) If you make an error on your "trip strip," you can erase it with alcohol and a tissue.

CONSTRUCTION MATERIALS:

Tagboard
Colored pens (indelible ink)
Strips of clear plastic (about 2 centimetres by 35 centimetres)
Scissors
A template (on tagboard) made from a gas station road map of your state
Tissues
Alcohol (the kind used in a spirit duplicating machine)

* *

NOTES:

(a) Use a large road map from a gasoline station. The maps in an atlas -- even a road atlas -- are usually too small.

(b) The easiest way to make your model 'trip strip' is to use the scale at the bottom of the map. Since 50 kilometres is about 31 miles, you should be able to make a trip strip which is marked off on a 50-kilometre scale. (Of course, it's then simple to subdivide it to get a 25-metre scale or such.)

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MAKE-IT-AND-TAKE-IT
Teacher Activity: Length

GOODIE: Metrically scaled map of the 48 contiguous states

HOW TO:

A. 1. Trace the outline of the model map and make dots (through the holes) to mark cities.

2. Using the small MAP OF THE UNITED STATES (48 CONTIGUOUS STATES ONLY), label the cities that you marked in Step 1.

B. The distance between Memphis and Omaha is 800 kilometres. Using this fact and the materials given, make an instrument which will allow a student to quickly approximate the distance (in kilometres) between any two cities on the map.

CONSTRUCTION MATERIALS:

Tagboard
Colored pens
Strips of cardboard, clear plastic, or whatever to make the kilometre scale in Part B
Scissors
Strips of paper longer than the distance from Omaha to Memphis
A large template map of the U.S.

* *

NOTES TO THE INSTRUCTOR:

1. To make the template map of the U.S., make a transparency of the map provided. (Before doing so, add the names and locations of any cities of local interest.) Project the map onto a sheet of tagboard. Copy the map. Cut out along the border and use a sharp object to punch holes at each city location.

2. To make the kilometre scale of Part B, cut a strip of paper which is the length of the distance between Memphis and Omaha. Fold the strip in half three times. The creases on the strip (mark them) will now correspond to 100-kilometre intervals. Transfer this to a stronger strip (cardboard, plastic, or whatever) to get a scale that is long enough to measure from Seattle to Miami. (You may wish to subdivide the scale to get 50-kilometre or 25-kilometre intervals.)

3. Do a similar activity for a state map. In doing so, locate two cities which are about 50 kilometres (31 miles) or about 100 kilometres (62 miles) apart so that Part B is possible.

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MAP OF THE UNITED STATES*
(48 CONTIGUOUS STATES ONLY)

*NOTE: THE DISTANCE BETWEEN OMAHA AND MEMPHIS IS 500 KILOMETRES.

MAKE-IT-AND-TAKE-IT
Teacher Activity: Length

GOODIE: A one-metre trundle wheel

HOW TO:
A. Cut a 70 centimetre length of wood.
B. 1. Using the model wheel, trace its circumference and mark its center on a piece of cardboard.
2. Cut out the wheel using a carpenter's utility knife (or some such razor-sharp tool).
C. Cover the edge of the wheel with the vinyl tape. (You may have to "notch" the tape in order to get it to fit smoothly on the side of the wheel.)
D. Using a metric tape measure, mark such points as you wish (1 metre, 50 centimetres) along the edge of the wheel being certain that increasing measures move clockwise around the wheel.
E. Drill a hole at the center of the wheel.
F. Measure the small copper "bushing" and use the pipe cutter to cut one of the same length. It should not protrude from the cardboard when placed (well, hammered) into the center hole.
G. Drill a hole in the center of the wooden handle about 2 centimetres from one end.
H. Assemble the trundle wheel as indicated on the separate page displayed at this station.
I. When the nut is correctly tightened to allow good movement of the wheel, put a few drops of the goo from the tube on the bolt just outside the nut. This will keep the nut from loosening.

CONSTRUCTION MATERIALS:
Lattice board
Thick cardboard (See Note below)
Vinyl duct tape
Copper tubing (just large enough for bolt to slip through)
for each wheel:
- 1 roundhead bolt (¼" diameter and 1½" length)
- 1 nut for the bolt
- 4 washers for the bolt

Drill with 1/4" bit
Small saw
Screwdriver
Pliers
Small pipe cutter
Hammer
Carpenter's utility knife (and extra razor blades)
Metric measuring tape
Sample of finished trundle wheel
Copy of ONE METRE TRUNDLE WHEEL ASSEMBLY DIAGRAM
A tube of Seal All or some other substance (found in hardware stores) used to prevent nuts from loosening

* *

NOTE: Triwall is best. If you don't have any, you can make it by gluing together sheets of cardboard taken from boxes. Rubber cement or wood glue (a powder mixed with water) are good adhesives.

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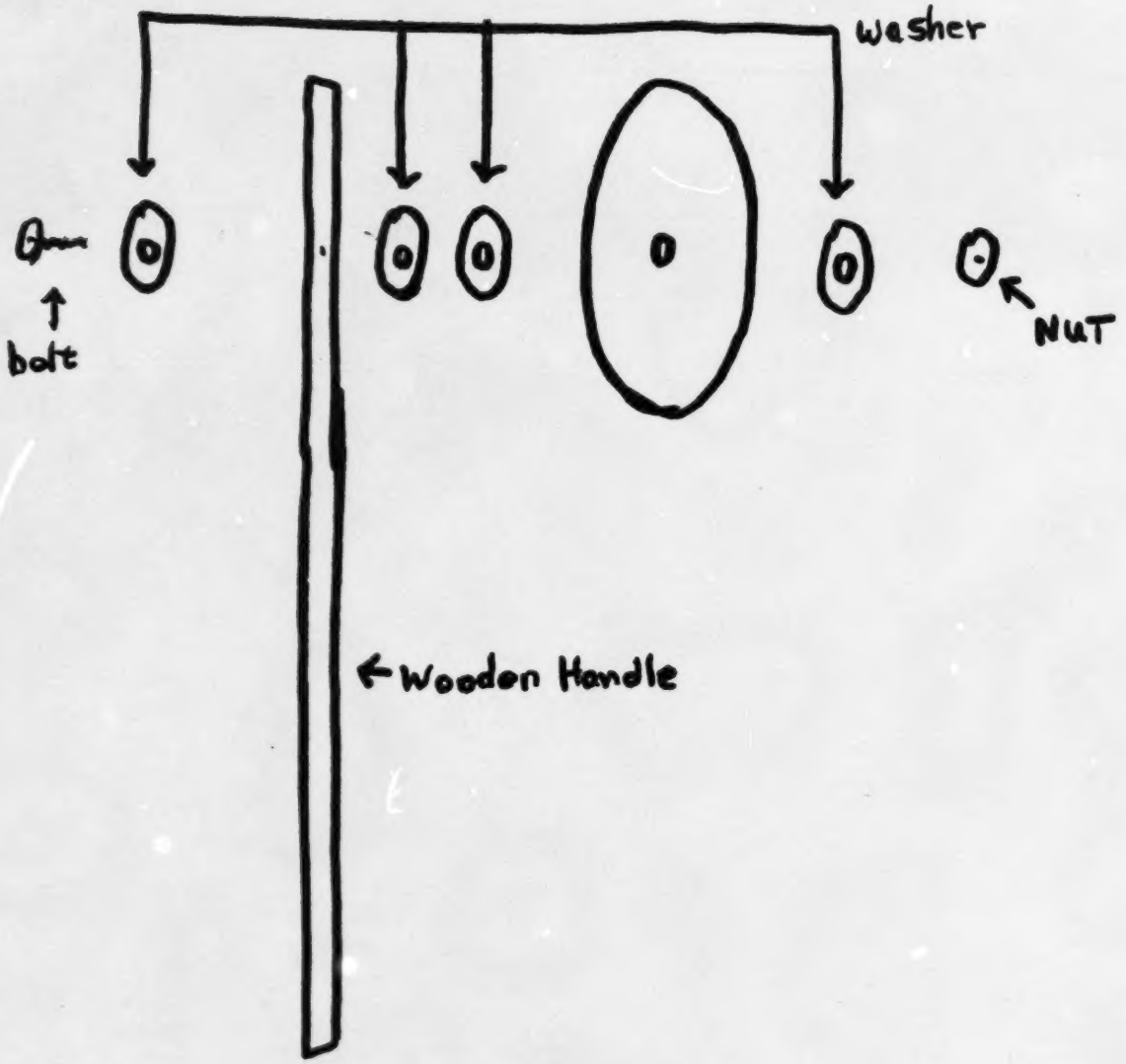
ONE-METRE TRUNDLE WHEEL ASSEMBLY DIAGRAM



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MAKE-IT-AND-TAKE-IT

Teacher Activity: Length

GOODIE: A decimetre-band ruler

HOW TO:

A. Cut a one-metre length of wood.

B. Make a copy of the decimetre stick at this station by

1. placing a piece of black tape along the entire length of the one-metre piece of wood,
2. placing 10-centimetre strips of yellow tape as shown on the sample, and
3. using clear plastic tape to secure any loose edges.

CONSTRUCTION MATERIALS:

Lattice board
Small saw
Black electrical tape
Yellow plastic tape
Clear plastic tape
Scissors
Small ruler marked in centimetres
Sample decimetre-band stick

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MAKE-IT-AND-TAKE-IT

Teacher Activity: Length

GOODIE: Height Chart

HOW TO:

A. Cut a 2-metre length of buckram

B. Using the metre stick provided, mark the buckram at 1-centimetre intervals. (If you write numerals on your chart, be careful to begin at the bottom of the chart and number upwards.)

C. Using the marking pens, decorate your height chart for use in your classroom.

CONSTRUCTION MATERIALS:

Buckram
Scissors
Marking pens
Metre sticks

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MAKE-IT-AND-TAKE-IT
Teacher Activity: Length

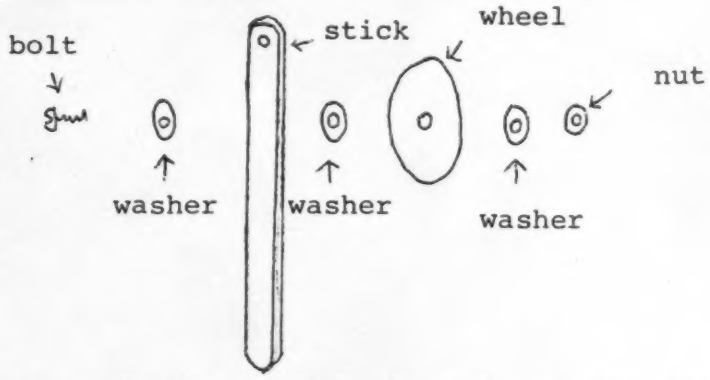
GOODIE: A decimetre trundle wheel

HOW TO:

A. 1. Using a compass, draw a circle with a radius of 16 millimetres on the cardboard. Cut it out with care.
2. Check the circumference of this wheel by wrapping a tape measure around the edge. (It should, of course, have a circumference of one decimetre.) Trim the wheel or cut a new one if necessary.
3. Drill a hole in the center of the wheel; widen it just enough to let the bolt pass into it easily.
4. Mark a starting point (and any other points you wish) along the edge of the wheel. Note that the measures should increase as you move clockwise around the wheel.

B. 1. Wrap one end of the stick tightly with masking tape. (This prevents the stick from splitting when you drill.) Slowly drill a hole about one centimetre from that end of the stick.
2. Carefully remove the tape.

C. 1. Assemble the wheel as indicated below:



2. Put some of the goo from the tube on the bolt just outside the nut. It prevents the nut from coming off.

CONSTRUCTION MATERIALS:

For each wheel you need the following:
- A popsicle stick
- *A roundhead bolt (6/32" diameter and 3/4" length)
- A nut for the bolt
- Three washers for the bolt
- Cardboard

Assembly also requires the following:
- *A drill with a 1/8" bit
- Scissors
- A metric measuring tape
- Masking tape
- A tube of Seal All or some other substance (found in hardware stores) used to prevent nuts from loosening

* *

*Note: The use of English measures to describe these items is distasteful and hopelessly inconsistent, but for the present it is (alas) necessary.

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MAKE-IT-AND-TAKE-IT

Teacher Activity: Mass

GOODIE: Metric masses of 50 grams and up

HOW TO: Although small masses (5 grams, 10 grams, and 20 grams) could be made from paper clips, the purchase of interlocking plastic one-gram cubes is advised. Such cubes have so many uses that they are a justifiable budget item. In this activity, then, we concentrate on the construction of large masses since larger masses (if you want good ones) are very expensive. The ones made here are <u>better</u> than most commercial ones and are much cheaper.

A. We'll start by making a 50-gram mass.

1. Place 50 of the one-gram masses on one pan of the balance.
2. Put one plastic bag inside another (for strength) Place these bags, a twist tie, and enough salt (grain, whatever) to make the pans balance.
3. When the pans balance, secure the mouth of the bags with the twist tie.
4. Use the pen to write '50' on the bag.
5. Repeat Steps 1-4 to make a second 50-gram mass.

B. Using the two 50-gram masses that you made in Part A, make <u>four</u> 100-gram masses.

C. Using the masses made in Parts A and B, make <u>one</u> 500-gram mass.

OPTIONAL: Using the masses made in Parts A, B, and C, make <u>one</u> 1000-gram mass.

CONSTRUCTION MATERIALS: To do Parts A-C, each person will need the following:

14 plastic bags (large enough to hold 500 grams)
7 twist ties
1000 grams of salt (grain, sand, whatever)

To do the OPTIONAL construction, each person will need the following:

2 plastic bags (large enough to hold 1000 grams)
1 twist tie
1000 grams of salt (grain, sand, whatever)

Assembly of any of the masses also requires the following:

A balance
A large spoon or scoop
A funnel (optional, but nice)
A marking pen (<u>permanent</u> ink)

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MAKE-IT-AND-TAKE-IT
Teacher Activity: Volume

GOODIE: Graduated Cylinders

HOW TO: Graduated cylinders (necessary to volume exercises) are quite expensive when purchased from commercial sources. However, homemade versions can be produced on a near-zero budget and with little loss in precision.

One of the student activities on volume (see MEASURE UP) is concerned with the production of consumable 250-millilitre cylinders which are graduated in 25-millilitre intervals. In this activity, we'll make a litre cylinder which is graduated in 50-millilitre intervals

A. Use the ruler and pen to draw a line straight down the side of your container. Let it dry for a minute or two.

B. With the help of the funnel, pour 50 millilitres of colored water into the 50-millilitre measuring cylinder.

C. Now pour this 50 millilitres of water into the container. Use the pen to mark the height of the water on the side of the container.

D. Write '50' (for 50 millilitres) next to the mark you made on the container.

E. Add another 50 millilitres of water to the glass. Mark the new water height and label it '100' (for 100 millilitres).

F. Continue the procedure until you have a 1000-millilitre (one litre) measuring container.

NOTES:
1. The cylinder made in the activity MEASURE UP could be used here (instead of a commercially made 50-millilitre cylinder).
2. This activity uses 50-millilitre graduations. If the cylinder is the right shape (not fat), you may be able to graduate it in 25-millilitre intervals.
3. This is a good activity for students. Supply your classroom with a large set of cylinders by having students collect containers and construct the cylinders as you have done.

CONSTRUCTION MATERIALS:
Funnel
Colored water
Felt-tipped marking pen (permanent ink)
Ruler
Commercially made graduated cylinder
Plastic (clear or translucent) or glass containers large enough to hold a litre of water

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MAKE-IT-AND-TAKE-IT
Teacher Activity: Game

GOODIE: Metric race track game

HOW TO:
A. Using the metre sticks, dice, game markers, and METRIC RACE RULES SHEET, play the game at least once.

B. Now make your own version of the game, modifying the rules or the dice as you think appropriate.

CONSTRUCTION MATERIALS:

Copies of METRIC RACE TRACK RULES SHEET
2 metre sticks (graduated in centimetres)
4 game markers (4 colors of centimetre cubes will do)
2 sample game dice labeled as follows

Die 1 - 0, 1, 2, 3, 4, 1
Die 2 - centimetre, centimetre, centimetre, decimetre, decimetre, decimetre

Some blank dice (hardwood cubes)
Colored pens (permanent ink)

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METRIC RACE TRACK RULES SHEET

MATERIALS: 2 metre sticks marked in centimetres
Different cclored marker for each player
2 special game dice

RULES:
1) Place the metre sticks end to end to form a "race track."
2) Each player now places his marker at one end of the track
3) Players roll dice in turn, each moving his marker the appropriate distance along the track as designated by the dice roll.
4) The first player to reach the end of the track is the winner.

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MAKE-IT-AND-TAKE-IT
Teacher Activity: Game

GOODIE: The kilogram game

HOW TO : A. Using the KILOGRAM RULES SHEET and the cards provided, play the game at least once.

B. Now make your own version(s) of the game, modifying the rules or the cards as you think appropriate.

CONSTRUCTION MATERIALS:
Copies of the KILOGRAM GAME RULES SHEET
A deck of game cards (see Note)
Blank cards
Colored pens (permanent ink)

Note: A deck of cards for this game consists of 52 cards labeled as follows:

2 cards labeled 0.75 kilogram
2 cards labeled 0.5 kilogram
4 cards labeled 0.25 kilogram
5 cards labeled 0.1 kilogram
2 cards labeled 450 grams
5 cards labeled 300 grams
5 cards labeled 250 grams
5 cards labeled 200 grams
10 cards labeled 100 grams
10 cards labeled 50 grams
2 cards labeled WILD CARD

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KILOGRAM GAME RULES SHEET

(2-4 players)

MATERIALS: A deck of game cards

RULES:

A. Shuffle the deck.

B. Deal 7 cards to each player. Place the rest of the deck face down on the table. Turn over the top of the deck to start a "discard pile."

C. Play begins with the person at the dealer's left. The player may draw the top card of the discard pile

OR

draw up the top <u>two</u> cards of the deck.

D. After a player draws, he may put down any collection of cards such that the sum of the measures named on those cards is one kilogram. This collection is called a <u>base</u>.

E. If a collection put down by a player does not have a value of one kilogram, the player must discard the card in the collection which has the highest value and loses his turn.*

F. A play must always discard one card at the end of his turn.

G. Play moves to the left.

H. Play stops when a player "goes out" (gets rid of all of his cards) or when no further play is possible.

I. <u>Scoring</u>

Each player receives 5 points for each base he has put down.

Each player also receives 1 point for each card in the bases he has put down.

A player who "goes out" gets 2 bonus points.

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*<u>Note</u>: A card labeled WILD CARD may be assigned any value from 50 grams to 500 grams that a player wishes to assign it at the time he puts down a base. However, he must declare its value (in grams) at the time he puts it down. If the resulting collection of cards does not have a value of one kilogram, the player must <u>discard the WILD CARD</u> and lose his turn.

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MAKE-IT-AND-TAKE-IT
Teacher Activity: Game

GOODIE: Metric '21' game

HOW TO: A. Play the game using the cards, ruler, and METRIC '21' RULES SHEET given. Play until one player accumulates 11 points or play for a maximum of 15 minutes.

B. Using the blank cards and some pens, create your own Metric '21' deck(s) and rules. In doing so, seek to

1. adjust the game for your students and

2. create variations on the rules or cards.

CONSTRUCTION MATERIALS:
A sample deck of Metric '21' cards
Copies of the METRIC '21' RULES SHEET
Rulers marked in centimetres
Blank cards
Colored pens

* *

NOTE TO THE INSTRUCTOR: A Metric '21' card deck contains 40 cards. Each card has a line segment (from 1 to 10 centimetres long) drawn on it. No lengths are indicated. There are 4 copies of each of the 10 kinds of cards possible.

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METRIC '21' RULES SHEET

MATERIALS: Deck of Metric '21' cards
A ruler marked in centimetres

RULES:

1. Shuffle the deck.
2. Each player is dealt a card with its face down on the table. (This card is called a "hole card;" a player does not show the face of his hole card to his opponents until the end of the hand.)
3. Each player is now dealt a card with its face up on the table.
4. Each player now looks at his hole card. He estimates the sum of the lengths of the line segments on his cards (in centimetres). The object of the game is to get a sum as close to 21 centimetres as possible without going over 21 centimetres.
5. Play begins with the person to the dealer's left. If the player wants an additional card, he says "hit me." The additional card is dealt face up. He can ask for as many such cards as he wishes; when he has all he wants, he says "I"ll stick."
6. When each player (including the dealer) has said "I'll stick," the hole cards are displayed. Each player declares what he believes to be the sum of the lengths of his cards. These declared sums are then checked with a ruler.
7. Scoring:

   2 points for declaring the correct sum
   1 point for being the person whose correctly declared sum was closest to (but not over) 21 centimetres.

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MAKE-IT-AND-TAKE-IT
Teacher Activity: Game

GOODIE: Metric equations game

HOW TO: A. Using a copy of the METRIC EQUATIONS RULE SHEET, a copy of the METRIC EQUATIONS WORKSHEET and the seven dice, play the game.

B. Now make your own version of the game. In doing so, be certain to consider altering the rules and dice to suit your students. You may be able to make several versions of the game by making alternate sets of dice.

CONSTRUCTION MATERIALS:
Copies of the METRIC EQUATIONS RULE SHEET
Copies of the METRIC EQUATIONS WORKSHEET
A sample set of metric equations dice (see Note)
Blank dice (hardwood cubes)
2 or more colors of pens (permanent ink)

* *

Note: A possible set of metric dice could be labeled as follows.

Die 1	(red pen):	0, 1, 2, 3, 4, 5
Die 2	(red pen):	6, 7, 8, 9, 10, 11
Die 3	(red pen):	12, 13, 14, 15, 16, 17
Die 4	(red pen):	1, 2, 17, 19, 20, 18
Die 5	(green pen):	litre, millilitre, centimetre, cubic centimetre, decimetre, cubic decimetre
Die 6	(green pen):	metre, centimetre, decimetre, decimetre, litre, cubic decimetre
Die 7	(green pen):	metre, centimetre, decimetre, centimetre, cubic centimetre, millilitre

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METRIC EQUATIONS RULE SHEET

(2-4 players)

MATERIALS: A set of Metric Equations dice
METRIC EQUATIONS WORKSHEET for each player

RULES:

1) Roll all of the dice. From all of the dice faces showing, select one number and one unit of measure.

2) Write a chosen number i any one of the boxes made of solid lines and write the unit name in any one of the boxes made of dashed lines.*

3) The first player to get a true sentence wins the round and scores 1 point.

4) Begin a new round using a blank METRIC EQUATIONS WORKSHEET.

5) The first player to get 3 points wins the game.

*Note: You could, for instance, choose to write the number in a box of the top equation and write the unit name in a box of the bottom equation of the WORKSHEET.

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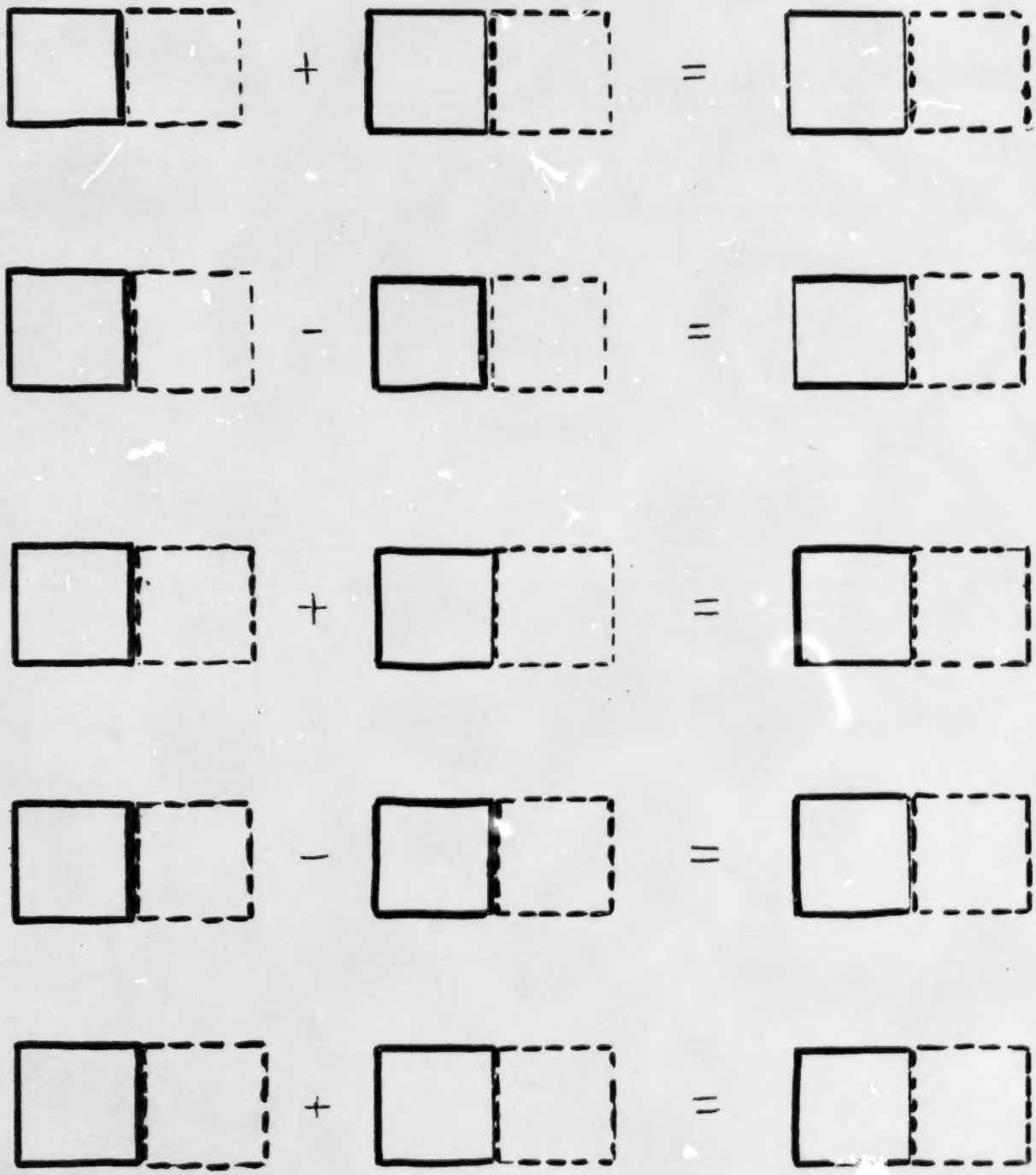
METRIC EQUATIONS WORKSHEET



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MAKE-IT-AND-TAKE-IT
Teacher Activity: Game

GOODIE: Metric concentration game

HOW TO: A. Using the cards and the METRIC CONCENTRATION RULES SHEET, play the game at least once.

B. Make your own version(s) of the game by modifying the rules or cards in any way you think appropriate.

CONSTRUCTION MATERIALS:
A deck of game cards (see Note below)
Copies of the METRIC CONCENTRATION RULES SHEET
Blank cards
Colored pens

Note: A deck of metric concentration cards consists of at least 20 cards. The labels for a suggested deck are given below.

Make two cards with each of the following labels.

1 metre
1 kilometre
1 cubic decimetre
10 decimetres
100 centimetres
1000 metres
1000 millimetres
1000 millilitres

Make four cards labeled:

1 litre

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METRIC CONCENTRATION RULES SHEET

(2 persons)

MATERIALS: A deck of Metric Concentration cards

RULES:

A. Shuffle the deck

B. Deal all the cards face down into four rows of five cards.

C. 1. The first player turns over any two cards. If they name equivalent measures (say, 1 litre and 1000 millilitres), he can pick them up. He can then turn over two more cards.

2. If two cards turned by a player do not name equivalent measures, they should again be turned face down and play moves to the opponent.

D. Play continues until no cards remain. The winner is the player with the larger number of cards.

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HAVE A METRIC PARTY
(Metric Recipes)

For a grand finale to your metric experiences, we suggest the following recipes. Not only do they reinforce the previous activities through measurement with many of the volume units, but they also provide some practical use of the previous activities.

Most of the recipes need a minimum of equipment which is easily obtained. Only one requires the use of an oven, hence, if an oven is not available for your use, make copies of the recipe for students to take home to use (you may, however, have to provide the measuring instruments and thermometer).

Of course, the most fun is eating the finished product

E N J O Y

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OLYMPIC CANDY

EQUIPMENT:

Mixing bowl and rubber spatula

Wax paper

Measuring cup

Spoon

INGREDIENTS:

100 ml of raw wheat germ

100 ml of powdered milk (not nonfat)

100 ml of honey

100 ml of CRUNCHY peanut butter

DIRECTIONS: Place above in mixing bowl in order given and mix well. If mixture is too sticky to handle add another 100 ml of powdered milk. This may now be worked with the hands like pie dough. On waxed paper, using hands, roll, shape and cut into the desired number of pieces.

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METRIC DRINKS

(A) Chocolate Milk

EQUIPMENT: Glasses that hold 300 ml
Spoon

INGREDIENTS: Cold water
75 ml nonfat dry milk
25 ml "Quick" chocolate

DIRECTIONS: Place 75 ml of nonfat dry milk into a glass, add 200 ml cold water and stir. Add 25 ml "Quick" chocolate, stir and drink.

(B) Kool Aid

EQUIPMENT: Glasses that hold 300 ml
Spoon

INGREDIENTS: Cold water
Presweetened Kool Aid

DIRECTIONS: Place 250 ml of cold water into a glass, add 25 ml of "Kool Aid," stir and drink.

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MARSHMALLOW TREATS

EQUIPMENT: A 33 cm x 5 cm x 5 cm loaf pan
Heat source
Kettle
Spoon
Spatula

INGREDIENTS: 65 ml margarine
500 ml marshmallow creme
1250 ml Rice Krispies cereal

DIRECTIONS:

Melt margarine over low heat, add marshmallow creme to melted margarine, stir until well blended, and cook over low heat 5 minutes longer, stirring constantly. Remove from heat, add Rice Krispies cereal, stir until well coated. Press mixture into 33 x 5 x 5 cm pan, cut into squares when cool.

VARIATIONS:

(a) For an added treat, add 250 ml of peanut butter, peanuts, or shelled sunflower seeds.

(b) Substitute corn flakes for part of the Rice Krispies.

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AVOCADO DIP

EQUIPMENT: Mixing bowl
Fork
Spoon
Knife

INGREDIENTS: 1 ripe avocado, peeled and pitted
10 ml lemon juice
60 ml dairy sour cream
5 ml instant minced onion
1 ml garlic salt
1 ml paprika
60 ml crumpled bacon

DIRECTIONS: Mash avocado, add remaining ingredients, blend and serve with celery sticks (2 cm long) or corn chips.

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POPCORN

EQUIPMENT: Popcorn popper

INGREDIENTS: Cooking oil
Popcorn

DIRECTIONS: Place 55 ml of cooking oil and 120 ml of popcorn into a popper and pop the corn.

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OATMEAL COOKIES

EQUIPMENT: Oven
Cookie sheet
Egg beater
Spoon
Mixing bowl

INGREDIENTS:

- 175 ml butter or margarine
- 250 ml firmly packed brown sugar
- 125 ml granulated sugar
- 1 egg
- 75 ml milk
- 250 ml all-purpose flour
- 3 ml salt
- 3 ml soda
- 625 ml Quaker Oats (quick or old fashioned, uncooked)
- 200 ml wheat germ
- 125 ml chopped nuts

DIRECTIONS: Beat together butter, sugars, egg, milk and vanilla. Add combined flour, salt and soda to butter mixture; mix well. Stir in oats, wheat germ and nuts. Drop by rounded teaspoonfuls onto greased cookie sheet. Bake in preheated moderate oven (190°C) 10 to 12 minutes. Makes about 4 dozen cookies.

VARIATIONS:
Substitute 250 ml 100% bran for wheat germ.
Substitute 125 ml sunflower seeds for nuts; add 125 ml raisins.
Substitute 250 ml semi-sweet chocolate pieces for nuts.
Substitute 250 ml raisins for nuts.
Substitute 125 ml shredded coconut for nuts.
Add 125 ml chopped dates or apricots.

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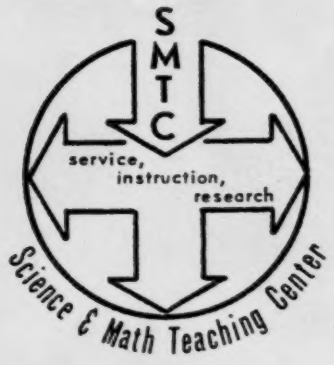
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